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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 259)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in November 1990 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC

1990

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 744 reports, journal articles and other documents originally announced in November 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE

ACCESSION NUMBER → N90-10834*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics. ← CORPORATE SOURCE

TITLE → AN EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF SLANTED BASE OGIVE CYLINDERS USING MAGNETIC SUSPENSION TECHNOLOGY

AUTHORS → CHARLES W. ALCORN and COLIN BRITCHER Nov. 1988 ← PUBLICATION DATE

CONTRACT NUMBER → (Contract NAG1-716)

REPORT NUMBERS → (NASA-CR-181708; NAS 1.26:181708) Avail: NTIS HC A05/MF A01 ← AVAILABILITY SOURCE

COSATI CODE → CSCL 01/1 ← PRICE CODE

An experimental investigation is reported on slanted base ogive cylinders at zero incidence. The Mach number range is 0.05 to 0.3. All flow disturbances associated with wind tunnel supports are eliminated in this investigation by magnetically suspending the wind tunnel models. The sudden and drastic changes in the lift, pitching moment, and drag for a slight change in base slant angle are reported. Flow visualization with liquid crystals and oil is used to observe base flow patterns, which are responsible for the sudden changes in aerodynamic characteristics. Hysteretic effects in base flow pattern changes are present in this investigation and are reported. The effect of a wire support attachment on the 0 deg slanted base model is studied. Computational drag and transition location results using VSAERO and SANDRAG are presented and compared with experimental results. Base pressure measurements over the slanted bases are made with an onboard pressure transducer using remote data telemetry.

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE

ACCESSION NUMBER → A90-13017*# Texas A&M Univ., College Station. ← CORPORATE SOURCE

TITLE → IN-FLIGHT BOUNDARY-LAYER TRANSITION MEASUREMENTS ON A SWEEP WING

AUTHORS → ANWAR AHMED (Texas A & M University, College Station), WILLIAM H. WENTZ (Wichita State University, KS), and R. NYENHUIS (Cessna Aircraft Co., Wichita, KS) ← AUTHORS' AFFILIATION

CONTRACT NUMBER → (Contract NAG1-104) Copyright ← JOURNAL TITLE

Journal of Aircraft (ISSN 0021-8669), vol. 26, Nov. 1989, p. 979-985. refs.

Flight tests were conducted at three different altitudes to detect transition on a smoothed test region of a swept-wing business jet wing using surface hot-film sensors and sublimating chemicals. Strong influence of sweep angle on transition location was observed when the aircraft was flown at some sideslip conditions to simulate changes in effective wing sweep angle. No effects of engine noise on transition were measured when different engine power settings were used. Flight instrumentation and ground data analysis techniques are described. Correlation was obtained between the hot-film sensor signals and sublimating chemicals for transition detection. Crossflow vortices were observed for one flight condition. Results of analyzed data for various flight-test conditions are presented.

Author

DECEMBER 1990

01

AERONAUTICS (GENERAL)

A90-46498

DESIGN OF COMPUTER-AIDED AIRCRAFT TESTING SYSTEMS. II [PROEKTIROVANIE AVTOMATIZIROVANNYKH SISTEM ISPYTANII AVIATSIONNOI TEKHNIKI. II]

IU. V. KOZHEVNIKOV and A. KH. KHAIRULLIN *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 1, 1990, p. 79-82. In Russian. Copyright

A matrix representation of a computer-aided aircraft testing system is proposed, and a generalized algorithm for designing such a system is presented. The design objectives are formulated, and the principal design stages are examined. Recommendations concerning the modeling of computer-aided aircraft testing systems and software support of the systems are given. V.L.

A90-46616

AIR TRANSPORTATION IN COMECON COUNTRIES [VOZDUSHNYI TRANSPORT STRAN-CHLENOV SEV]

VLADIMIR M. TIKHONOV *Moscow, Izdatel'stvo Transport*, 1989, 304 p. In Russian. refs Copyright

The main trends in the development and integration of the air transportation system in COMECON countries are examined. The structure of COMECON organizations in the air transportation field is discussed, along with cooperative planning and economic efforts. Directions of scientific and technological progress in the air transportation field in COMECON countries up to the year 2000 are projected. B.J.

A90-46719#

ONE WING FOR TWO AIRLINERS - COMPUTER SCREENS ARE TECHNICAL TRAILBLASERS FOR A UNIQUE WING

New-Tech News (ISSN 0935-2694), no. 2, 1990, p. 12-15. Copyright

New A330 and A340 wing technology, manufacture, and testing are described and it is pointed out that the same control functions, lifts, and brake aids will serve both the twin-engine and four-engine propulsion systems. The wings are 30 meters in length and moving components are incorporated onto the leading or trailing edges of the rigid wing box of a wing component. The landing flaps, ailerons, spoilers, and slats comprise moving components and themselves are similar to wings. The technological and dimensional requirements of the actuators for the surface components of the Airbus are described. Each power pack in the wing requires a control and function system that operates via cable, hydraulic lines, and slewing gears, while the onboard computer in the A340 has taken over the control, checking, and precise execution of the spoiler's functions. Wing technology and assembly, including computational and graphic utilization of computers in the design, assembly, mock-up, and testing of the aircraft, are described. L.K.S.

A90-46927#

THE IMPACT OF TOTAL QUALITY MANAGEMENT (TQM) AND CONCURRENT ENGINEERING ON THE AIRCRAFT DESIGN PROCESS

DANIEL P. SCHRAGE (Georgia Institute of Technology, Atlanta) IN: *Vertical Lift Aircraft Design Conference*, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 21 p. refs

In the aerospace industry results from a recent American Institute of Aeronautics and Astronautics (AIAA) quality survey showed a broad-based recognition that quality is a major engineering issue, that basic systems engineering processes as presently practiced need to be improved, that there are significant shortfalls in engineering skills and basic engineering education needed to support quality improvement, and that AIAA as a professional society should get more involved in this issue. This paper will attempt to put in perspective the impact of TQM and concurrent engineering on the aircraft design process and review some of the essential features for successful incorporation. Author

A90-46928#

PRACTICAL ASPECTS OF EUROPEAN COLLABORATION

R. V. SMITH (Westland Helicopters, Ltd., Yeovil, England) IN: *Vertical Lift Aircraft Design Conference*, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 12 p.

This paper reviews the practical issues which arise in international collaboration, based upon the experience of Westland Helicopters Limited. The opportunity is taken to indicate the reasons why collaborative procurement is increasingly considered to be necessary. Cost factors which arise in collaboration are discussed, together with the practical implications of collaboration for the industrial consortium, national procurement agencies, participating companies, and individual participants. Having laid out the challenges to be expected in a collaborative program, the paper presents a check list of factors which are likely to result in a successful collaboration. The most important of these are considered to be the presence of common commercial interests industrially, and the strength of support to the program from the participating governments. The future strength of the helicopter industry will depend upon its ability to recognize and meet the challenges of collaboration. Author

A90-46929#

ADVOCATING INTERNATIONAL COOPERATION: THE EUROFAR PROGRAM - AN EXAMPLE AND A HOPE

JEAN RENAUD (Aerospatiale, Paris, France), GIULIANO MONTI (Agusta S.p.A., Milan, Italy), and GEOFFROY VENN (Westland Helicopters, Ltd., Yeovil, England) IN: *Vertical Lift Aircraft Design Conference*, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 21 p. refs

The phase 1 of the Eurofar program (European Future Advanced Rotorcraft) is a three-year (1988 - 1990) feasibility phase, launched within the Eureka framework, with the participation of some major European aeronautical companies and research agencies, and devoted to the introduction of the tilt-rotor as a new transportation system. This paper recalls the basic commandments for international cooperation and the attempt of Eurofar to fulfill them in terms of program establishment, activities sharing, organization

01 AERONAUTICS (GENERAL)

and management. The program's main features related to vehicle predesign, operational problems, civil marketing, and military applications, are reviewed, mainly regarding specification requirements influence. An extended international cooperation is seen as the only way to promote a worldwide tilt-rotor introduction. Author

A90-47707*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ROTORCRAFT PURSUIT-EVASION IN NAP-OF-THE-EARTH FLIGHT

P. K. A. MENON, V. H. L. CHENG (NASA, Ames Research Center, Moffett Field, CA), and E. KIM IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1259-1268. refs (Contract NAG2-463)

(AIAA PAPER 90-3455) Copyright

Two approaches for studying the pursuit-evasion problem between rotorcraft executing nap-of-the-earth flight are presented. The first of these employs a constant speed kinematic helicopter model, while the second approach uses a three degree of freedom point-mass model. The candidate solutions to the first differential game are generated by integrating the state-costate equations backward in time. The second problem employs feedback linearization to obtain guidance laws in nonlinear feedback form. Both approaches explicitly use the terrain profile data. Sample extremals are presented. Author

A90-48510

AEROSPACE - COLLECTED TRANSLATIONS OF SELECTED PAPERS

Xian, People's Republic of China, Northwestern Polytechnical University, 1990, 73 p. Translation. For individual items see A90-48511 to A90-48517.

Topics presented include the effect of annealing on dislocation forms and properties of Ti-2Al-1.5Mn alloy, the design and practice of high frequency electromagnetic levitation melting, and the coupling factor method for studying elastic motion of a flight vehicle. Also discussed are a longitudinal stability analysis for deformable aircraft, exceptions to the $C(n \text{ beta, dyn})$ criterion for aircraft stability at high angles of attack, the control of solid-liquid interface position during directional solidification, and the thickness of a pyrolysis layer in the ablation model for silica-phenolics composite material. R.E.P.

A90-48826#

INNOVATION AND INVESTMENT FOR SURVIVAL AND PROSPERITY - THE NEW BATTLE OF BRITAIN

IVAN R. YATES (British Aerospace, PLC, London, England) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. refs (AIAA PAPER 90-3189) Copyright

The paper presents the aeronautical history of the United Kingdom from the Battle of Britain in summer of 1940 to the present concentrating on the main economic and political constraints on technology. The roles of the Supermarine Spitfire and Hawker Hurricane aircraft are outlined, along with the first radar towers. The earlier part of the period between after the Battle and the supersonic era is presented from the German side by focusing on the Messerschmitt Me262 twin jet-engined aircraft. The development step into the supersonic regime is characterized by the Fairey Delta FD2 which became the prototype for the French Mirage series of fighters, and the English Electric Lightning. International military collaboration in the last 30 to 40 years is discussed, and emphasis is placed on technology development, expenditures on research and development, different sectors of economy involved, industrial-financial factor, and education, training, and skills affecting productivity. V.T.

A90-48828#

INTEGRATED PRODUCT DEVELOPMENT (IPD) AT GENERAL DYNAMICS FORTH WORTH

EDWARD M. PETRUSHKA and C. DALE LITTLE (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 15 p.

(AIAA PAPER 90-3192) Copyright

The evolution of integrated product development (IPD) is reviewed in terms of its fundamental elements of guidance principles, enabling electronic tools, and cultural acceptance. Past experiences from 1971 are covered, including such products as F-111, YF-16 prototype, and F-16 full-scale programs. The current environment with the USAF Advanced Tactical Fighter, USN A-12, and National Aerospace Plane programs is described, along with the existing IPD principles, further electronic-tool development, continuing cultural changes, benefits derived, and lessons learned in the areas of management responsibilities, organizational aspects, and development and application of enabling tools. Future changes in the basic elements of IPD and their impacts are considered. V.T.

A90-48829#

IMPLEMENTATION OF INTEGRATED PRODUCT DEVELOPMENT

H. R. KESSLER (Hughes Aircraft Co., Radar Systems Group, El Segundo, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 7 p. (AIAA PAPER 90-3194) Copyright

Simultaneous engineering or integrated product development (IPD) efforts in the area of the physical design and manufacturing planning are outlined, with focus placed on CAD techniques enhancing IPD. An advanced airborne expendable-decoy project and an F/A-18-radar upgrade program are described as two pilot programs. Emphasis is placed on the process-definition process, flowcharting the process as the means of providing the technical guidelines how to do IPD, teamwork as the way of conquering the social impediments to IPD, social and cultural changes, and implementation methods. Next steps and challenges involving the creation of teams and teaming as an implementation strategy as well as a necessary set of tools are assessed, and suggestions for getting started are given. V.T.

A90-48840#

AGING FLEET STRUCTURES WORKING GROUP ACTIVITIES

T. J. COMERFORD (Boeing Commercial Airplanes, Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. (AIAA PAPER 90-3219) Copyright

Recent incidents involving older aircraft have focused worldwide attention on the safety of the aging jet transport fleet. This paper will provide a brief history of aging fleet activities at Boeing, review the background behind the formation of the aging fleet Structures Working Groups (SWG) and give a status report on their current activities. SWG tasks, as chartered by the industry steering committee (or Airworthiness Assurance Task Force), are to: (1) review service bulletins and make recommendations for mandatory modification; (2) develop an extensive corrosion prevention and control program; (3) review basic maintenance programs; (4) review the supplemental Structural Inspection programs for potential improvements; and (5) assess repair quality as it relates to aging aircraft. All SWG tasks, with the exception of the maintenance program review, are anticipated to result in regulatory actions. The first two tasks are complete and covered by FAA Airworthiness Directives or Notices of Proposed Rule Making. The remaining three tasks have been reviewed and defined by the SWGs and are currently in progress. Author

N90-27617# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

AIRCRAFT INTEGRATED MONITORING SYSTEMS

Jan. 1990 590 p The 15th symposium held in Aachen, Fed. Republic of Germany, 12-14 Sep. 1989 (DLR-MITT-90-04; ISSN-0176-7739; ETN-90-97539) Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The 28 contributions presented at the 15th symposium on Aircraft Integrated Monitoring Systems (AIMS) are reported. The investigations cover all methods and systems which are used for monitoring and recording the performance of aircraft, including their subsystems, and flights. The task is to improve safety, reliability, and economy of flight operation or maintenance. The data can be used for early fault or dangerous situation detection, diagnosis, preventive measures, and improvement of methods and systems.

N90-27646# Assistant Secretary of Defense (Production and Logistics), Washington, DC.

MODEL DESIGNATION OF MILITARY AEROSPACE VEHICLES

JOSEPH NOTARO Jan. 1990 136 p
(PB90-206301; DOD-4120.15-L) Avail: NTIS HC A07/MF A01
CSC L 01/2

DoD 4120.15-L is a list of approved Mission Design Series (MDS) designations for all approved military aerospace vehicles in the DoD inventory (aircraft and missiles); i.e., F-15A (Eagle), B-52G (Stratofortress) and LGM-25G (Minuteman III). The list displays MDS, manufacturer, popular name, engine data, using service, and a brief description. GRA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A90-45845

AIAA APPLIED AERODYNAMICS CONFERENCE, 8TH, PORTLAND, OR, AUG. 20-22, 1990, TECHNICAL PAPERS. PARTS 1 & 2

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. Pt. 1, 494 p.; pt. 2, 495 p. For individual items see A90-45846 to A90-45932.

Copyright

The present conference discusses topics in CFD methods and their validation, vortices and vortical flows, STOL/VSTOL aerodynamics, boundary layer transition and separation, wing airfoil aerodynamics, laminar flow, supersonic and hypersonic aerodynamics, CFD for wing airfoil and nacelle applications, wind tunnel testing, flight testing, missile aerodynamics, unsteady flow, configuration aerodynamics, and multiple body/interference flows. Attention is given to the numerical simulation of vortical flows over close-coupled canard-wing configuration, propulsive lift augmentation by side fences, road-vehicle aerodynamics, a shock-capturing method for multidimensional flow, transition-detection studies in a cryogenic environment, a three-dimensional Euler analysis of ducted propfan flowfields, multiple vortex and shock interaction at subsonic and supersonic speeds, and a Navier-Stokes simulation of waverider flowfields. Also discussed are the induced drag of crescent-shaped wings, the preliminary design aerodynamics of missile inlets, finite wing lift prediction at high angles-of-attack, optimal supersonic/hypersonic bodies, and adaptive grid embedding for the two-dimensional Euler equations. O.C.

A90-45846*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

CFD VALIDATION FOR AERODYNAMIC FLOWS - CHALLENGE FOR THE '90'S

JOSEPH G. MARVIN and TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1-13. refs
(AIAA PAPER 90-2995)

The process of computational fluid dynamics (CFD) validation

is described from two perspectives, numerical error validation and physical model validation. Errors associated with time and space discretization, grid refinement, numerical dissipation, and level of solution convergence, are all possible sources of numerical error. The second aspect of CFD code validation is associated with the governing equations and the physical models, e.g., chemistry and turbulence models. This type of validation requires comparisons with carefully conducted experiments and is the primary aspect of the validation process discussed in this paper. Examples of validation are shown for selected Reynolds-averaged Navier-Stokes codes for conditions from transonic through hypersonic. Since code applications are becoming more complex, it no longer suffices to use data from surface or integral quantities alone to provide the required validation. Flow field surveys and experimental boundary condition measurements are emerging as critical data that must be obtained for CFD code validation. Progress in the overall level of validation is shown to be improving. However, future challenges remain, some of which are enumerated. Author

A90-45847*#

SUPERSONIC FLOW COMPUTATIONS FOR AN ASTOVL AIRCRAFT CONFIGURATION

S. V. RAMAKRISHNAN, K. Y. SZEMA, S. R. CHAKRAVARTHY, and B. L. BIHARI IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 14-20. refs
(Contract NAS1-17492)

(AIAA PAPER 90-2997) Copyright

A multi-zonal, unified, space/time marching method has been used to solve the Euler and Reynolds-averaged Navier-Stokes equations for supersonic flow past an Advanced Short Take-Off and Vertical Landing (ASTOVL) aircraft configuration. Lift, drag, and pitching moment values obtained from the computations compare well with wind-tunnel measurements. The calculations demonstrate the capability of the method used to accurately predict design parameters such as lift, drag and pitching moment for very complex aircraft configurations. Author

A90-45848#

AIRPLANE - EXPERIENCES, BENCHMARKS AND IMPROVEMENTS

JOHN C. VASSBERG and KATHLEEN B. DAILEY (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 21-35. Research supported by Douglas Aircraft Co. refs

(AIAA PAPER 90-2998) Copyright

Applications of and recent improvements to the AIRPLANE program (developed by Jameson and Baker) are presented. This unstructured-mesh Euler method is capable of solving the inviscid transonic flow about complex three-dimensional aircraft configurations. Preliminary validations for the ONERA-M6 wing are made with comparisons to test data and a structured-mesh Euler code. Geometric capabilities of the present method are illustrated with solutions about simple, semi-complex and extremely complex aerodynamic configurations. Computational resources and manpower requirements are benchmarked for the ONERA-M6 wing and a generic MDC Tri-Jet transport; the computers utilized for this survey include CONVEX, CRAY, Hitachi and IBM. Author

A90-45849*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NUMERICAL SIMULATION OF THE VISCOUS FLOW AROUND A SIMPLIFIED F/A-18 AT HIGH ANGLES OF ATTACK

YEHA M. RIZK, LEWIS B. SCHIFF, and KEN GEE (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 36-58. refs
(AIAA PAPER 90-2999) Copyright

A numerical method developed for solving the viscous flow

around three-dimensional complex configurations is presently used to simulate the flow around a simplified F/A-18 configuration encompassing forebody, wing, leading-edge extension, faired-over inlet, and deflected wing leading-edge flaps, at Mach 0.243 and 30.3 deg angle of attack. The computational results show the details of the flowfield structure, including primary, secondary, and tertiary separation lines, the development of forebody and leading-edge extension vortex, and the burst of this vortex. A grid-refinement study is conducted to assess the effect of grid characteristics on solution accuracy. Substantial agreement is obtained between these results and flight data. O.C.

A90-45850* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NUMERICAL SIMULATION OF THE EFFECTS OF VARIATION OF ANGLE OF ATTACK AND SWEEP ANGLE ON VORTEX BREAKDOWN OVER DELTA WINGS

J. A. EKATERINARIS (NASA, Ames Research Center; Navy-NASA Joint Institute of Aeronautics, Moffett Field, CA) and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 59-67. refs (AIAA PAPER 90-3000) Copyright

In the present investigation of the vortical flowfield structure over delta wings at high angles of attack, three-dimensional Navier-Stokes numerical simulations were conducted to predict the complex leeward flowfield characteristics; these encompass leading-edge separation, secondary separation, and vortex breakdown. Attention is given to the effect on solution accuracy of circumferential grid-resolution variations in the vicinity of the wing leading edge, and well as to the effect of turbulence modeling on the solutions. When a critical angle-of-attack was reached, bubble-type vortex breakdown was found. With further angle-of-attack increase, a change from bubble-type to spiral-type vortex breakdown was predicted by the numerical solution. O.C.

A90-45851#

NUMERICAL SIMULATION OF VORTICAL FLOWS OVER A STRAKE-DELTA WING AND A CLOSE COUPLED DELTA-CANARD CONFIGURATION

RACHEL GORDON (Texas A & M University, College Station) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 68-78. refs

(AIAA PAPER 90-3002) Copyright

Computations of vortical flows over a strake-delta wing and a delta-canard wing configuration are carried out using the Non Linear Vortex Lattice Method (NLVLM). The computations are carried out for sharp leading edge wings in subsonic flow at moderate-to-high angles of attack. The calculated values of the lift, pitching moment and aerodynamic center of pressure are in very good agreement with experimental data for angles of attack below vortex breakdown. The calculated results for the surface pressure distribution are in qualitative agreement with experimental data. Graphical visualization of the computed flow fields at several cross flow planes shows the interaction process that occurs between the vortex emanating from the leading edge of the strake (canard) and the vortex from the leading edge of the wing. Comparison of the computed flow fields with experimental results shows that the features of the flow fields are well simulated by the present method. Author

A90-45852#

NUMERICAL SIMULATION OF VORTICAL FLOWS OVER CLOSE-COUPLED CANARD-WING CONFIGURATION

J. M. A. LONGO and A. DAS (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 79-88.

Research supported by DLR and MBB. refs (AIAA PAPER 90-3003) Copyright

The numerical solution of Euler equations is very well suited for computing the vortical flow fields of slender delta wings. The basic requirement is to have proper grid structuring in regions of high flow gradients, such that one obtains reliable and consistent results for arbitrary combinations of grid topologies and numerical algorithm. Having assured the capability and efficiency of the numerical approach in yielding good flow resolution the present study was aimed to find all details regarding the interaction of the vortex systems of a canard-delta wing combination. Extensive analysis was undertaken to compare the velocities, pressures, and loss of total pressure in the spiraling vortical flows with the canard-on and -off configurations. The results reveal some interesting physical phenomena including the condition for onset of vortex bursting at the canard and on the main wing. The favorable interaction of the canard vortex on the wing-flow field could be confirmed. Author

A90-45853#

NUMERICAL STUDY OF ASYMMETRIC AIR INJECTION TO CONTROL HIGH ANGLE-OF-ATTACK FOREBODY VORTICES ON THE X-29 AIRCRAFT

B. S. ROSEN and W. H. DAVIS (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 89-99. refs

(AIAA PAPER 90-3004) Copyright

High angle-of-attack forebody vortex control concepts under consideration for flight test are studied using 3D viscous computational flow methodology. Calculations are made for the X-29 forward fuselage geometry at low speed and high angle-of-attack. A brief overview of the computational method includes the approach for simulating jets blowing through the leeward forebody surface, just downstream of the nose. First, a fully asymmetric vortical flow is computed, being induced by a skewed elliptical nose tip fairing. These results compare favorably with wind tunnel oil flow photographs of naturally occurring asymmetric flow over the complete X-29 aircraft. Next, calculations are performed for asymmetric (forward and aft blowing) forebody jets. Computed flow fields, axial distributions of cross-sectional side force, and total forebody yawing moments induced by asymmetric jets are consistent with those obtained both numerically and experimentally by other investigators. A final calculation is aimed at studying a rocking motion observed at certain angles-of-attack on a sub-scale model. Computations for symmetric forebody jets blowing downstream of a skewed elliptical nose tip fairing agree with experimental data in that symmetric forebody jets reduce vortical flow asymmetry. Author

A90-45854#

REDUCTION OF THE SIDE FORCE ON POINTED FOREBODIES THROUGH ADD-ON TIP DEVICES

V. J. MODI, C. W. CHENG, A. MAK (British Columbia, University, Vancouver, Canada), and T. YOKOMIZO (Kanto Gakuin University, Kanagawa, Japan) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 100-108. refs

(Contract NSERC-A-2181)

(AIAA PAPER 90-3005) Copyright

Subsonic, incompressible aerodynamics of a conical pointed forebody with a cylindrical base is studied at subcritical Reynolds number of around 100,000. The main objective is to assess effectiveness of delta-strakes, porous tips, nose-boom tips, and their combinations in alleviating the undesirable side force. Results suggest that, among the tip devices tested, a delta-strake with an aspect ratio of 2 can reduce the side force by around 96 percent in the angle of attack (α) range of \pm or - 50 deg and at zero roll (ϕ). Even with $\alpha = +50$ deg and ϕ ranging over 0 - 360 deg, the minimum reduction was observed to be 57 percent. Author

A90-45855* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

THE EFFECT OF TURBULENCE MODELS ON THE NUMERICAL PREDICTION OF THE FLOWFIELD ABOUT A PROLATE SPHEROID AT HIGH ANGLE OF ATTACK

KEN GEE, RUSSELL M. CUMMINGS, and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 109-123. refs (Contract NCC2-564)

(AIAA PAPER 90-3106) Copyright

The F3D thin-layer Navier-Stokes code presently used to numerically investigate the three-dimensional separated flow about a prolate spheroid at high incidence analyzes the effect of different turbulence models on the flowfield solution and the characteristics of the predicted flow. The Johnson-King (1984) model is applied in order to evaluate the importance of modeling nonequilibrium effects in predicting flow about a slender body at high incidence; the computations in question are for steady-state, fully turbulent flow. Insight is gained into the effects of turbulence models on flow characteristics, and model effects on the accurate prediction of highly separated and vortical flows about a slender body are demonstrated. O.C.

A90-45856#

APPLICATION OF A NEW VISUALIZATION METHOD TO HELICOPTER ROTOR FLOW

J. S. STEINHOFF (Tennessee, University, Tullahoma) and R. H. G. MUELLER IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 124-131. Research supported by DFG and University of Tennessee. refs

(AIAA PAPER 90-3006) Copyright

This paper presents an application and extension of a new flow visualization method to complex flows over helicopter rotor blades. With the method, qualitative determination as well as quantitative measurements of the airflow are possible. The basic idea of the method is to reduce thin, sharp-edged smoke trails by shooting very small burning metal pellets through the region of interest at high speed. These smoke traces can be placed as initially straight lines in any region of the helicopter rotor, even intersecting the rotor disk. After they are produced, the smoke traces follow the flow. The images of these traces in multi-exposure or multi-flash photographs then give a visualization of the flow field. The complicated nature of the helicopter rotor flow which can be visualized with the technique will be presented by several photographs showing, for example, the early stages of development of a tip vortex and turbulent flow patterns. In addition, the possibility of obtaining quantitative information about the flow field will be described. Author

A90-45857#

EULER PROCEDURE FOR CALCULATION OF THE STEADY ROTOR FLOW WITH EMPHASIS ON WAKE EVOLUTION

E. KRAEMER, J. HERTEL, and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 132-142. refs

(AIAA PAPER 90-3007) Copyright

An Euler procedure that is optimized for the application of steady helicopter rotor flow with special emphasis on the complex blade vortex interaction being especially sophisticated in the hover case is presented. In very contrast to the commonly used numerical schemes the capability of vortex capturing involved within the Euler equations is utilized to avoid the coupling with external wake models. Due to the rotational character of the rotor flow the starting vortex delays enormously the evolution of the steady state. This subject is discussed from the numerical point of view in correlation with the real physical phenomenon. Since only the steady state

solution is of interest, a method is presented that uses the results of a fast linear wake calculation exclusively as an initial solution for an Euler calculation. The comparison of numerical results with experimental data shows good agreement and is presented.

Author

A90-45858* Westland Helicopters Ltd., Yeovil (England).

EXPERIMENTAL AND NUMERICAL STUDY OF THE BRITISH EXPERIMENTAL ROTOR PROGRAMME BLADE

ALAN BROCKLEHURST (Westland Helicopters, Ltd., Yeovil, England) and EARL P. N. DUQUE (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 143-160. Research supported by the Ministry of Defence of England. refs (AIAA PAPER 90-3008) Copyright

Wind-tunnel tests on the British Experimental Rotor Programme (BERP) tip are described, and the results are compared with computational fluid dynamics (CFD) results. The test model was molded using the Lynx-BERP blade tooling to provide a semispan, cantilever wing comprising the outboard 30 percent of the rotor blade. The tests included both surface-pressure measurements and flow visualization to obtain detailed information of the flow over the BERP tip for a range of angles of attack. It was observed that, outboard of the notch, favorable pressure gradients exist which ensure attached flow, and that the tip vortex also remains stable to large angles of attack. On the rotor, these features yield a very gradual break in control loads when the retreating-blade limit is eventually reached. Computational and experimental results were generally found to be in good agreement. Author

A90-45859#

PROPULSIVE LIFT AUGMENTATION BY SIDE FENCES AS APPLIED TO JAPAN'S EXPERIMENTAL STOL AIRCRAFT, ASKA

MASATAKA MAITA, KATSUMI TAKEDA, HAMAKI INOKUCHI (National Aerospace Laboratory, Chofu, Japan), TAKASHI INOUE, and MASUMICHI KURIYAMA (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 161-167. refs (AIAA PAPER 90-3009) Copyright

A static ground-based study was conducted of the aerodynamic characteristics of the external upper-surface-blowing (USB) propulsive-lift configuration of the Japanese Quiet STOL Experimental Aircraft, designated 'ASKA'. A comparison was made of flows associated with two configurational alternatives: one employing side-fences, the other using vortex generators. The USB concept incorporating side-fences achieved an effective enhancement of the exhaust flow attachment, as well as an improvement in such other respects as aeroacoustics and/or structural thermal loading. O.C.

A90-45860#

SURFACE FLOW ON A FLAT PLATE INDUCED BY A SUPERSONIC JET EXHAUSTING NORMALLY INTO A LOW SPEED CROSSFLOW

XIN ZHANG and DAVID W. HURST (Southampton, University, England) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 168-177. Research supported by the Ministry of Defence Procurement Executive. refs (AIAA PAPER 90-3011) Copyright

A study is presented on surface flow on a flat plate induced by a supersonic jet exhausting normally into a low speed crossflow. Cold jets in both underexpanded and overexpanded modes were produced by Mach 1.4 and 1.7 convergent-divergent nozzles and introduced into a low speed crossflow. The surface flow was found to be quite different from that induced by a low speed jet. Outstanding time-mean surface flow features include a strong

entrainment flow near the jet exit and a wake flow downstream of the crossflow. The dominant flow parameters are the jet pressure ratio and the mass flow ratio. The jet mode is also important in determining the surface normal force coefficient. The scaling parameter in determining the center of pressure is the mass flow ratio. The surface normal force coefficient, however, is less well defined by the mass flow ratio.

Author

A90-45862* # National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

NAVIER-STOKES SIMULATION OF TRANSONIC AFTERBODY FLOWS WITH JET EXHAUST

WILLIAM B. COMPTON, III (NASA, Langley Research Center, Hampton, VA) and KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 189-200. refs (AIAA PAPER 90-3057) Copyright

Three-dimensional Navier-Stokes simulations have been made for the transonic flow past a nonaxisymmetric nozzle typical of those advocated for advanced fighter airplanes. Jet exhaust simulation is evaluated as are the Baldwin-Lomax (1978) and Goldberg (1986) turbulence models. Solutions are presented for Mach numbers of 0.80 and 0.94 at 0-deg angle of attack and a Reynolds number of 20×10 to the 6th. The numerical results are compared to wind-tunnel data. They show that including the jet exhaust in the calculations gives the most accurate solution near the nozzle exit. Also, the two turbulence models predict considerably different flow fields.

Author

A90-45863#

AN IMPROVED CANOPY STIFFNESS SCALING LAW FOR DETERMINING OPENING TIME OF FLAT CIRCULAR PARACHUTES

EUGENE E. NIEMI, JR. (Lowell, University, MA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 201-212. Research supported by the U.S. Army. refs (AIAA PAPER 90-3058) Copyright

In the design and development of parachutes, it is often convenient to rely on scale models for drop testing or wind tunnel testing. The use of scale models for drop testing can save significant cost and time in the development cycle. For the scaling of parachutes, there are several unsettled questions concerning the scaling of the fabric stiffness. Because the parachute scaling laws are not completely understood, the interpretation of model test data poses numerous problems. For example, model parachutes tend to open quicker, with a larger scaled opening shock force, than their full-scale counterparts. This paper reports an investigation of the parachute scaling laws applicable to the opening process, and identifies a better correlation parameter for opening time than those currently available.

Author

A90-45864#

SIMULATION OF TIME-DEPENDENT VISCOUS FLOWS USING CENTRAL AND UPWIND-BIASED FINITE-DIFFERENCE TECHNIQUES

E. J. HALL, R. A. DELANEY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and R. H. PLETCHER (Iowa State University of Science and Technology, Ames) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 213-223. Research supported by the General Motors Corp. and Iowa State University of Science and Technology. refs (Contract NSF CBT-82-11713) (AIAA PAPER 90-3012) Copyright

Four time-marching numerical methods are compared for predicting unsteady viscous flows in two spatial dimensions. Algorithms utilizing central spatial differencing include the explicit hopscotch and Runge-Kutta schemes, and an implicit scheme of

the Beam-Warming variety. A fourth approach based on an implicit formulation utilizing upwind-biased differencing via the TVD approach is also evaluated. Each scheme is initially verified for the unsteady flow resulting from an oscillating flat plate. A final comparison is performed for the unsteady vortical flow resulting from an impulsively started cylinder. Predicted results are compared with analytical and experimental data and flow visualization.

Author

A90-45867#

EFFECTS OF ONSET FREE-STREAM TURBULENCE ON THE PERFORMANCE CHARACTERISTICS OF AN AIRFOIL

JON A. HOFFMANN (California Polytechnic State University, San Luis Obispo) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 245-250. refs (AIAA PAPER 90-3025) Copyright

The performance characteristics of a NACA 0015 airfoil with an aspect ratio of 2.9 were obtained as a function of onset free-stream turbulence at a Reynolds number of 250,000. The peak lift coefficient was found to increase by 30 percent as the free-stream turbulence intensity increased from 0.25 to 9 percent, while no significant changes in the slope of the lift coefficient - angle of attack curve or the drag coefficients at each angle of attack occurred. For studies with onset free-stream turbulence intensities larger than 3 percent, hysteresis and the laminar separation bubble were eliminated and a significant delay in separation occurred.

Author

A90-45868#

2D VS. 3D - SELECTION OF PRESSURE DISTRIBUTIONS TO DELAY SEPARATION ON WINGS

W. H. MASON (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 251-258. refs (AIAA PAPER 90-3026) Copyright

A series of pressure distributions are examined computationally to determine which pressure distributions result in the most favorable separation characteristics under two-dimensional, infinite swept, and constant isobar swept tapered wing flow conditions. The results show that a good pressure distribution for two-dimensional conditions is not necessarily the best when used on a highly swept wing. Specifically, simple sweep theory is not accurate as a boundary layer approach for sweeps above 30 deg. For highly tapered wings, the local sweep angle near the trailing edge appeared to control the location of boundary layer separation, and, in some cases, a two-dimensional calculation is better than an equivalent infinite swept wing calculation with a forward element line effective sweep angle.

Author

A90-45870#

THE EFFECT OF SEPARATION ON TURBULENT BOUNDARY LAYER CHARACTERISTICS OVER A SMOOTH SURFACE AT MACH 6.0

P. J. DISIMILE (Cincinnati, University, OH) and N. E. SCAGGS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 273-283. Research supported by USAF. refs (AIAA PAPER 90-3028) Copyright

The present study of the compressible turbulent boundary layer characteristics under the influence of a wedge-induced adverse pressure gradient, whose tests were conducted at Mach 6 for unit Re of 33, 66, and 98 million/m, has yielded surface pressure distribution data confirming the two-dimensionality of the boundary layer flow throughout the interaction region. A comparison of data for identical test conditions in the case of a rough surface shows

an order-of-magnitude upstream movement of the point of separation. O.C.

A90-45871*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A COMPUTATIONAL STUDY OF INCIPENT LEADING-EDGE SEPARATION ON A 65-DEG DELTA WING AT $M = 1.60$

S. NAOMI MCMILLIN, JAMES L. PITTMAN, and JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 284-294. refs (AIAA PAPER 90-3029) Copyright

A computational study on a 65-deg delta wing at a freestream Mach number of 1.60 has been conducted by obtaining conical Reynolds-averaged Navier-Stokes solutions on a parametric series of geometries which varied in leading-edge radius and/or circular-arc camber. The computational results showed that increasing leading-edge radius or camber can delay the onset of leading-edge separation on the leeside of a delta wing at a specific angle of attack. Reynolds number was varied from 1×10 to the 6th to 5×10 to the 6th for a turbulent boundary-layer and was shown to have a minor effect on the effectiveness of leading-edge radius and/or camber in delaying the onset of leading-edge separation. Both laminar and turbulent boundary-layer models were investigated at a Reynolds number of 1×10 to the 6th, and the predicted flow pattern was found to change from attached flow for the turbulent boundary-layer model to separated flow for the laminar boundary-layer model. Based upon these results, three wind-tunnel models have been designed to be tested in the Langley Unitary Plan Wind Tunnel. Author

A90-45873*# General Motors Corp., Indianapolis, IN.

3D EULER ANALYSIS OF DUCTED PROPPAN FLOWFIELDS

EDWARD J. HALL and ROBERT A. DELANEY (General Motors Corp., Allison Gas Turbines Div., Indianapolis, IN) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 306-313. refs (Contract NAS3-25270) (AIAA PAPER 90-3034) Copyright

A numerical method is presented for predicting the steady inviscid flow through a ducted propfan based on a time-marching solution of the three-dimensional Euler equations. A four-stage multiple-block Runge-Kutta finite volume numerical technique, utilizing implicit residual smoothing and a blended second and fourth difference dissipation, is applied to predict the transonic flowfield about both single-rotation and counter-rotations ducted rotors. Counter-rotation predictions are based on an average-passage system of equations approach. Calculations are performed for both a single sheared H-type grid system and a multiple-block grid system incorporating a C-type grid about the cowl. Numerical results are compared with experimental data for two cases: a low speed ducted propeller and a 1.15 pressure ratio fan stage. Author

A90-45874#

VALIDATION OF PROPELLER SLIPSTREAM CALCULATIONS USING A MULTI-BLOCK EULER CODE

J. L. KUIJVENHOVEN (Fokker Aircraft, Amsterdam, Netherlands) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 314-322. refs (AIAA PAPER 90-3035) Copyright

A three-dimensional multiblock Euler code has been developed for the analysis of the flow around arbitrary aircraft configurations including propeller slipstream simulations. Algebraic and elliptic techniques are used to discretize the finite flow domain. The Euler propeller simulation method is applied to the Fokker 50 turboprop aircraft and compared with flight-test data. Good agreement has been achieved for a wide range of flow conditions. Author

A90-45875#

THICK AIRFOIL DESIGNS FOR A HALE VEHICLE

DOUGLAS R. HALL (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 323-331. (AIAA PAPER 90-3036)

Three thick airfoils were designed in support of the conceptual design of two high altitude, long endurance unmanned air vehicles. The initial conceptual design study identified the need for a 30 percent thick airfoil with low drag and good lift characteristics at a Reynolds of one million. Due to the low drag requirement, the airfoils were designed with large extents of natural laminar flow. The low Reynolds number requirement introduced the problem of eliminating or minimizing the effects of laminar separation bubbles. Two 26 percent thick airfoils were designed to meet the needs of the initial vehicle. The first airfoil demonstrated the feasibility of designing thick airfoils at low Reynolds number with large extents of a laminar boundary layer. One goal that was achieved for the second airfoil, was to minimize the effect of laminar separation bubbles. Although the characteristics of the conceptual vehicle changed, the third airfoil was designed to incorporate the lessons learned in the design of the first two airfoils. The accuracy of the Eppler Airfoil Design And Analysis code was verified by testing the airfoils in the wind tunnel. The first two airfoils were tested in the subsonic tunnel at David Taylor Research center. Author

A90-45876#

RAPID PREDICTION OF SLENDER-WING AIRCRAFT DYNAMICS

L. E. ERICSSON and H. H. C. KING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 332-345. Research supported by the Lockheed Missiles and Space Co., Inc. refs (AIAA PAPER 90-3037) Copyright

Most aerospace vehicles, although designed for hypersonic cruise at low angles of attack, often have to perform rapid maneuvers at high angles of attack from low supersonic down to low subsonic speeds. There is, therefore, a need for rapid prediction of the nonlinear high-alpha vehicle dynamics of slender-wing aircraft in that speed range. The present paper describes such a prediction method, which can account for the nonlinear dynamic effects of leading edge vortices at angles of attack, yaw, and roll. A comparison with existing experimental results shows that the accuracy of the prediction is satisfactory for preliminary design as long as breakdown of the leading edge vortices does not occur. Author

A90-45877*# Naval Postgraduate School, Monterey, CA.

SCHLIEREN STUDIES OF COMPRESSIBILITY EFFECTS ON DYNAMIC STALL OF AIRFOILS IN TRANSIENT PITCHING MOTION

M. S. CHANDRASEKHARA (Navy-NASA Joint Institute of Aeronautics, Monterey, CA), S. AHMED (Navy-NASA Joint Institute of Aeronautics, San Jose, CA), and L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 346-356. refs (Contract AF-AFOSR-87-0029; AF-AFOSR-88-0010) (AIAA PAPER 90-3038) Copyright

Compressibility effects on the flowfield of an airfoil executing rapid transient pitching motion from 0 - 60 degrees over a wide range of Mach numbers and pitching rates were studied using a stroboscopic schlieren flow visualization technique. The studies have led to the first direct experimental documentation of multiple shocks on the airfoil upper surface flow for certain conditions. Also, at low Mach numbers, additional coherent vortical structures were found to be present along with the dynamic stall vortex,

whereas at higher Mach numbers, the flow was dominated by a single vortex. The delineating Mach number for significant compressibility effects was 0.3 and the dynamic stall process was accelerated by increasing the Mach number above that value. Increasing the pitch rate monotonically delayed stall to angles of attack as large as 27 degrees. Author

A90-45878#**ACTIVE FLOW CONTROL ON LOW REYNOLDS NUMBER AIRFOILS**

M. SHEPHELOVICH and D. KOSS (Israel Aircraft Industries, Ltd., Engineering Center, Lod) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 357-366. refs (AIAA PAPER 90-3039) Copyright

This paper presents the results of a preliminary investigation on the application of oscillatory two-dimensional devices to control flow separation on airfoils at low Reynolds numbers. This work is an extension of the concept which was originally developed for the control of the rate of spreading in mixing layers. Results indicate the possibility to improve the post-stall behavior of airfoils and extend their operational capability beyond the original lower Reynolds number limit. A number of practical applications of the concept were identified and recommended. Author

A90-45879#**AERODYNAMIC CHARACTERISTICS OF FORWARD SWEEP**

S. C. GUPTA (Institute of Armament Technology, Poona, India) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 367-374. refs (AIAA PAPER 90-3041) Copyright

A theoretical study has been conducted of forward-swept wing FSWs characteristics relative to those of back-swept wings, with respect to pressure distributions, flap loads, optimal camber warp, and optimal flap scheduling in both subsonic and supersonic flow conditions. Attention is given to the cases of low-to-moderate aspect ratio wings, which exhibit low compressibility effects in virtue of their low profile drag, as well as low radar signatures. The reduction of FSW lift due to its symmetrical sections can be remedied through the incorporation of a conically cambered chord geometry without forfeiture of low drag values. O.C.

A90-45880#**DESIGN FOR A NATURAL LAMINAR FLOW GLOVE FOR A TRANSPORT AIRCRAFT**

G. REDEKER, K. H. HORSTMANN, H. KOESTER (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), P. THIEDE, and J. SZODRUCH (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 375-384. refs (AIAA PAPER 90-3043) Copyright

A laminar flow 'glove' has been designed for part of the span of the wing of an experimental transport aircraft, in order to evaluate limiting N-factors due to Tollmien-Schlichting instability, as well as those due to crossflow instability, for transition-characteristics prediction. A detailed analysis is conducted of the stability behavior of the wing glove, which, by changing both flight and glove geometry parameters, can be varied over a wide range to obtain transitions via either of the two instabilities. A three-dimensional calculation of the design-modified wing confirmed that the design pressure distribution was obtained in the glove region. O.C.

A90-45882#**NATURAL LAMINAR FLOW - A WIND TUNNEL TEST CAMPAIGN AND COMPARISON WITH FLIGHT TEST DATA**

R. HENKE, F. X. MUENCH (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany), and A. QUAST (DLR, Brunswick, Federal Republic of Germany) IN: AIAA Applied Aerodynamics

Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 393-400. Research supported by BMFT. refs

(AIAA PAPER 90-3045) Copyright

Tests have been conducted with a laminar flow glove-equipped wing half-span aircraft model, in a wind tunnel whose flow quality and profile drag had previously been ascertained. A match is made between the wing flow transition data obtained and pressure distribution data yielded by flight tests of a wing-gloved aircraft. The need for the simultaneous use of numerous and diverse flow characterization techniques, such as optical methods, frequency-resolving sensors, and pressure distribution sensors, is presently confirmed and elaborated. O.C.

A90-45883#**NUMERICAL INVESTIGATION OF LAMINAR SEPARATED VISCOUS TRAILING-EDGE FLOW USING TRIPLE-DECK THEORY**

F. A. MANSFIELD (U.S. Navy, Naval Weapons Center, China Lake, CA) and ODUS R. BURGGRAF IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 401-410. refs (AIAA PAPER 90-3046) Copyright

A efficient time-marching numerical algorithm has been developed for solving the triple-deck problem for supersonic laminar separated trailing-edge flows. The accuracy of the numerical method is tested for the case of a flat plate at angle of incidence alpha below stall. A range of numerical solutions are then presented for angle of incidence beyond stall in the form of streamline and shear contour plots. Some numerical difficulties for greater than 2.7 were encountered. Author

A90-45885*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

F-18 HIGH ALPHA RESEARCH VEHICLE SURFACE PRESSURES - INITIAL IN-FLIGHT RESULTS AND CORRELATION WITH FLOW VISUALIZATION AND WIND-TUNNEL DATA

DAVID F. FISHER (NASA, Flight Research Center, Edwards, CA), DANIEL W. BANKS (NASA, Langley Research Center, Hampton, VA), and DAVID M. RICHWINE (PRC Systems Services Co., Edwards, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 421-451. refs (AIAA PAPER 90-3018) Copyright

Flight tests with the NASA F-18 high-alpha research vehicle (HARV) have yielded pressure distributions at angles of attack from 10 to 50 deg, at Mach 0.23 to 0.6, at five fuselage forebody stations and three on the leading-edge extensions (LEXs). Correlations are made between these data and both previously obtained HARV flow visualizations and wind tunnel model test results. The general trend is one in which the forebody's maximum suction pressure peaks increase in magnitude, after their first appearance at alpha of about 19 deg, with increasing alpha. LEX pressure-distribution trends involve the inward progression of the maximum suction peaks, an increase in the magnitude of the maximum pressure peaks up to pressure core breakdown, and the decrease and general flattening of the pressure distribution beyond the LEX primary vortex breakdown. O.C.

A90-45886#**A LASER SHEET FLOW VISUALIZATION AND AERODYNAMIC FORCE DATA EVALUATION OF A 3 PERCENT YF-17 FIGHTER AIRCRAFT MODEL AT HIGH ANGLES OF ATTACK**

SHESHAGIRI K. HEBBAR and DAVID H. LEEDY (U.S. Naval Postgraduate School, Monterey, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 452-462. Research

supported by the U.S. Navy. refs
(AIAA PAPER 90-3019)

Flow visualization by laser-sheet smoke illumination, and force and moment measurements, have been obtained by low speed wind tunnel tests of a 3-percent YF-17 lightweight fighter scale model at high alpha in order to identify flow phenomena and flow regions pertinent to the design and performance of supermaneuverable aircraft. The asymmetric shedding of vortices generated by the slender nose and leading-edge extensions of the model dominate the flow at 45-65 deg angles-of-attack; the roll and yaw angles exert considerable influence on vortex development, and consequently on flow behavior, at these extreme attack angles. O.C.

A90-45887#

3-D ANALYSIS OF LASER MEASUREMENTS OF VORTEX BURSTING ON A CHINED FOREBODY FIGHTER CONFIGURATION

KENNETH C. CORNELIUS (Wright State University, Dayton, OH) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 463-473. refs

(Contract F49620-88-C-0053)

(AIAA PAPER 90-3020) Copyright

Enhanced dynamic control of fighter aircraft at high angle-of-attack may be obtained through the blowing of suitably placed pneumatic jets in the nose region of the forebody, which alters the character of the asymmetric development of vortical separations and thereby permits controlled side-force and yawing moments to be activated by variations of jet momentum. Attention is presently given to the comparative advantages of axisymmetric jet, two-dimensional jet, or jet-exit boundary condition-varying configurations, as means to the enhancement or amplification of favorable jet/vortical interactions with local aerodynamic surfaces. An examination is accordingly conducted of the physics of vortex breakdown, in order to deepen understanding of the various blowing schemes. The Rosby parameter set governing instability is affected by a jet maximizing entrainment and imparting axial momentum to the outer helical streamlines of vortex flow. O.C.

A90-45890*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MULTIPLE VORTEX AND SHOCK INTERACTIONS AT SUBSONIC, TRANSONIC, AND SUPERSONIC SPEEDS

GARY E. ERICKSON (NASA, Langley Research Center, Hampton, VA), JOHN A. SCHREINER (NASA, Ames Research Center, Moffett Field, CA), and LAWRENCE W. ROGERS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 497-516. refs

(AIAA PAPER 90-3023) Copyright

A wind tunnel experiment was conducted at subsonic, transonic, and supersonic speeds of the vortex-vortex and vortex-shock interactions about a tailless, general research fighter model having chine-like forebody strakes faired into a 55 deg cropped delta wing. The present paper isolates the results obtained at angle of attack 20 deg and free-stream Mach = 0.6 to 1.6, which include off-surface and on-surface flow visualizations, two-component laser velocimeter measurements, and wing upper surface static pressure distributions. Increasing the Mach number decreased the direct interaction (intertwining) of the forebody strake and wing vortex cores. An early bursting of the wing vortex occurred at free-stream Mach = 0.8, where the flow field was in transition from the intertwining vortices characteristic of the lower subsonic speeds to the decoupled vortices at the transonic and supersonic speeds. The vortex interaction and breakdown were sensitive to the character of the secondary boundary layer separation on the wing, which may be shock-induced at free-stream Mach = 0.8 to 0.95.

Author

A90-45891*# Colorado Univ., Boulder.

COMPUTATIONAL SIMULATION OF FLOWS ABOUT HYPERSONIC GEOMETRIES WITH SHARP LEADING EDGES

KEVIN D. JONES and F. CARROLL DOUGHERTY (Colorado, University, Boulder) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 517-527. refs

(Contract NAG1-880)

(AIAA PAPER 90-3065) Copyright

Hypersonic waverider design has become an important concern in the aerospace industry. As one part of an inverse design effort for waveriders, work has been done to apply existing Euler and Navier-Stokes flow solvers to hypersonic geometries with sharp leading edges. Previously, calculations were done on bodies with rounded leading edges or with conical solutions for the nose initial conditions. In this paper, solutions are computed about waveriders and conical shapes with sharp leading edges without resorting to either shortcut. All solutions show attached shocks with fully supersonic flows at the nose and along the leading edges. Flows about several waverider shapes are shown, as well as a preliminary cone with inlet calculation to study the shock/inlet interaction.

Author

A90-45892#

NAVIER STOKES SIMULATION OF WAVERIDER FLOWFIELDS

K. M. ISAAC (Missouri-Rolla, University, Rolla), J. B. MILES (Missouri-Columbia, University, Columbia), and J. R. LIAO IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 528-538. Research supported by the University of Missouri. refs

(AIAA PAPER 90-3066) Copyright

The three-dimensional, laminar flowfield associated with waveriders has been analyzed in the present paper by numerical simulation of the Navier-Stokes equations. The numerical method uses the flux difference splitting algorithm. A 'trans-finite' grid system which takes advantage of the conical nature of the problem has been used. Both Euler and viscous solutions have been obtained. Results of a zero angle-of-attack and a 5 degree angle-of-attack case, respectively, are presented. The analysis to date has dealt with the forebody only. Surface pressure coefficients are compared with experimental data. Skin friction coefficients are calculated and lift and drag values are estimated. The skin friction, lift and drag values are compared with previous analytic estimates and they are found to be in reasonably good agreement. The study provides valuable preliminary insight into the feasibility of using waverider configurations for aircraft design.

Author

A90-45893*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EXPERIMENTAL AND COMPUTATIONAL SURFACE AND FLOW-FIELD RESULTS FOR AN ALL-BODY HYPERSONIC AIRCRAFT

WILLIAM K. LOCKMAN, SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA), and JOSEPH W. CLEARY (Elort Institute, Sunnyvale, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 539-549. refs

(AIAA PAPER 90-3067) Copyright

The objective of the present investigation is to establish a benchmark experimental data base for a generic hypersonic vehicle shape for validation and/or calibration of advanced computational fluid dynamics computer codes. This paper includes results from the comprehensive test program conducted in the NASA/Ames 3.5-foot Hypersonic Wind Tunnel for a generic all-body hypersonic aircraft model. Experimental and computational results on flow visualization, surface pressures, surface convective heat transfer, and pitot-pressure flow-field surveys are presented. Comparisons of the experimental results with computational results from an upwind parabolized Navier-Stokes code developed at Ames demonstrate the capabilities of this code.

Author

A90-45894#

CALCULATION OF THREE-DIMENSIONAL VISCOUS AND INVISCID HYPERSONIC FLOWS USING SPLIT-MATRIX MARCHING METHODS

S. MENNE and C. WEILAND (MBB Space Systems Group, Munich, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 550-559. refs (AIAA PAPER 90-3070) Copyright

Two split-matrix marching methods for hypersonic flows are presented: a space marching method for inviscid flow and a time-integration marching method for viscous flow. For both methods, the solution algorithm is explained. Flow calculations of the flow over a hypersonic vehicle show that the methods allow an economic computation of flows over complex geometries with sharp shocks and no spurious oscillations without using any artificial damping. Author

A90-45895#

DESIGN OF SUPERSONIC WINGS USING AN OPTIMIZATION STRATEGY COUPLED WITH A SOLUTION SCHEME FOR THE EULER EQUATIONS

JUERGEN SCHOENE (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 560-570. refs (AIAA PAPER 90-3060) Copyright

The present paper describes an approach for the design of wings at supersonic speed. It is based on a numerical optimization technique coupled with a solution scheme for the Euler equations. The wings studied here are either conical or three-dimensional delta wings with a straight leading edge. The surface is given by a set of Legendre polynomials. The coefficients of this set are the design parameters in the optimization task; the object function is the lift-to-drag ratio. Results of the optimization are shown for conical wings at an onflow Mach number of 4.8. Here, the design of a wing without a crossflow shock at the upper surface for a relative high lift coefficient is demonstrated. Additionally, the influence of geometrical and aerodynamic parameters on the optimization result is examined. Finally, one example for the design of a three-dimensional wing is given. Author

A90-45896#

INDUCED DRAG OF WINGS WITH HIGHLY SWEPT AND TAPERED WING TIPS

MARK A. DEHAAN (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 571-581. refs (AIAA PAPER 90-3062) Copyright

A study has been conducted to investigate the validity of recent claims which assert that wings with highly tapered and swept tips have lower induced drag at subsonic speeds than those which do not maintain such characteristics. The legitimacy of the computational technique used to arrive at the conclusion that these planar wings, also referred to as crescent-moon-shaped wings, create induced drag less than the minimal value obtained with the classical unswept elliptical wing is also examined. Computational results obtained with the Douglas higher-order surface panel method indicate that the induced drag, at a given lift, is reduced by sweeping back the wing tip; however, the level of the induced drag for wings with crescent-moon-shaped planforms is not below the lifting-line theoretical minimum. In addition, the level of improvement in wing efficiency found in this computational analysis due to highly swept and tapered wing tips is significantly lower than that which has been published by other investigators. Author

A90-45897#

3D TRANSONIC NACELLE AND WINGLET DESIGN

W. F. LIN, A. W. CHEN, and E. N. TINOCO (Boeing Commercial

Airplanes, Seattle, WA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 582-591. refs (AIAA PAPER 90-3064) Copyright

This paper discusses the application of a predictor/corrector design method originally developed at the NASA Langley Research Center. The ability to couple the predictor/corrector method to existing CFD analysis tools (or flow solvers) gives promise of a design technology that can be applied to a variety of practical aerodynamic engineering problems. This paper will describe some of the initial experiences of adapting the NASA predictor/corrector design method which include its application to the design of the fan cowl of a turbofan engine and to the design of a partial chord winglet. Author

A90-45898*# Arizona Univ., Tucson.

SIDSLIP-INDUCED STATIC PRESSURE ERRORS IN FLIGHT-TEST MEASUREMENTS

EDWIN K. PARKS (Arizona, University, Tucson), RALPH E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA), and DUC TRAN IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 592-597. refs (AIAA PAPER 90-3082) Copyright

During lateral flight-test maneuvers of a V/STOL research aircraft, large errors in static pressure were observed. An investigation of the data showed a strong correlation of the pressure record with variations in sideslip angle. The sensors for both measurements were located on a standard air-data nose boom. This paper describes an algorithm based on potential flow over a cylinder that was developed to correct the pressure record for sideslip-induced errors. In order to properly apply the correction algorithm, it was necessary to estimate and correct the lag error in the pressure system. The method developed for estimating pressure lag is based on the coupling of sideslip activity into the static ports and can be used as a standard flight-test procedure. The paper discusses the estimation procedure and presents the corrected static-pressure record for a typical lateral maneuver. It is shown that application of the correction algorithm effectively attenuates sideslip-induced errors. Author

A90-45899#

WIND TUNNEL STUDIES OF SUPPORT STRUT INTERFERENCE ON A 3 PERCENT YF-17 FIGHTER AIRCRAFT MODEL AT HIGH ANGLES OF ATTACK

SHESHAGIRI K. HEBBAR and JOHN D. SOMMERS (U.S. Naval Postgraduate School, Monterey, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 598-607. Research supported by the U.S. Navy. refs (AIAA PAPER 90-3083)

A low-speed wind-tunnel investigation was conducted to examine the aerodynamic interference caused by support struts on a three-percent scale model of the YF-17 lightweight fighter prototype. The study was undertaken at the request of NASA-Ames Research Center to obtain background data in support of an upcoming investigation in which a full-scale F/A-18 will be mounted in the 80 x 120 foot wind tunnel. Force and moment measurements were made for various strut configurations using a precision six-component strain gage balance. Flow visualization studies were also conducted using smoke injected upstream of the model and illuminated by a laser sheet to highlight flow phenomenon around the model. Results of the investigation indicate that only minor aerodynamic interference was caused by the strut configurations tested. Of the configurations tested, it was determined by a subjective analysis that a slight reduction in interference could be realized by attaching the forward struts to the wing tips and the aft strut to the tail hook pivot point. Author

A90-45900#**AN AEROFOIL TESTING TECHNIQUE FOR LOW SUPERSONIC SPEEDS IN AN ADAPTIVE FLEXIBLE-WALLED WIND TUNNEL**

M. J. GOODYER (Southampton, University, England) and N. J. TAYLOR IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 608-621. Research supported by SERC and Royal Aerospace Establishment. refs
(AIAA PAPER 90-3086) Copyright

Current two-dimensional adaptive wall research at Southampton University is directed toward producing interference-free wind tunnel data for Mach numbers ranging from 0.95 to 1.4. This paper describes the initial development of a technique designed for low supersonic speeds. The principles on which the technique is based are outlined together with a brief overview of the supporting technology. Methods have been devised to start supersonic flow in the test section and to streamline the walls. Two models - a simple wire and a high blockage aerofoil - have been tested and the results of streamlining at Mach 1.2 are presented. Cancellation of bow shock reflections has been demonstrated and the potential advantages of testing large models in a relatively shallow test section are discussed. While it is recognized that testing experience is limited and that the technique is still in the early stages of development, the prospects of successful completion are considered to be good. Author

A90-45901#**AN EXPERIMENTAL INVESTIGATION OF SUPERSONIC FLOW OVER TWO CAVITIES IN TANDEM**

XIN ZHANG and JOHN A. EDWARDS (Cambridge, University, England) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 622-631. Research supported by the Ministry of Defence Procurement Executive. refs
(AIAA PAPER 90-3087) Copyright

A study is presented on supersonic flow over two rectangular cavities arranged in tandem at Mach 1.5, 2.5 and 3.5. For the purposes of this paper cavities are chosen in which the oscillatory properties are due either to a fluid resonant phenomenon or to a fluid dynamic phenomenon. These are defined as Type A and Type B cavities respectively. At Mach 1.5 and 2.5 the flow in a Type A cavity is found to be completely altered by a preceding Type B cavity. When the Type B cavity is preceded by another Type B cavity only the level of the unsteady pressures and the high frequency modes of the oscillation are affected. When a Type A cavity preceded a Type B cavity only small quantitative changes are noted in the oscillatory behavior. The influence of the spacing between the two cavities is also addressed. Author

A90-45902#**NAVIER-STOKES PREDICTIONS OF PITCH DAMPING FOR FINNED PROJECTILES USING STEADY CONING MOTION**

PAUL WEINACHT and WALTER B. STUREK (U.S. Army, Ballistic Research Laboratory, Aberdeen Proving Ground, MD) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 632-642. refs
(AIAA PAPER 90-3088)

Previous theoretical investigations have proposed that the side force and moment acting on a body of revolution in steady coning motion could be related to the pitch-damping force and moment. Here, this approach has been applied to produce the first known Navier-Stokes predictions of the pitch damping for finned projectiles. The flow field about finned kinetic energy projectiles in steady coning motion has been successfully computed using a parabolized Navier-Stokes computation. The computational predictions have been compared with pitch damping coefficients determined from range firings and good agreement with the range data. This computational approach provides a significant predictive capability for the design of kinetic-energy projectiles whose terminal

ballistic performance can be degraded by moderate levels of yaw at the target. Author

A90-45908*# Analytical Methods, Inc., Redmond, WA. ANGLE-OF-ATTACK VALIDATION OF A NEW ZONAL CFD METHOD FOR AIRFOIL SIMULATIONS

SUNGYUL YOO, J. MICHAEL SUMMA, and DANIEL J. STRASH (Analytical Methods, Inc., Redmond, WA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 704-712. refs
(Contract NAS2-12962; NAS2-13194)
(AIAA PAPER 90-3077) Copyright

The angle-of-attack validation of a new concept suggested by Summa (1990) for coupling potential and viscous flow methods has been investigated for two-dimensional airfoil simulations. The fully coupled potential/Navier-Stokes code, ZAP2D (Zonal Aerodynamics Program 2D), has been used to compute the flow field around an NACA 0012 airfoil for a range of angles of attack up to stall at a Mach number of 0.3 and a Reynolds number of 3 million. ZAP2D calculation for various domain sizes from 25 to 0.12 chord lengths are compared with the ARC2D large domain solution as well as with experimental data. Author

A90-45909*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.**RELATIVE EFFICIENCY AND ACCURACY OF TWO NAVIER-STOKES CODES FOR SIMULATING ATTACHED TRANSONIC FLOW OVER WINGS**

DARYL L. BONHAUS and STEPHEN F. WORNOM (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 713-731. refs
(AIAA PAPER 90-3078) Copyright

In the present study, two codes which solve the three-dimensional Thin-Layer Navier-Stokes (TLNS) equations are used to compute the steady-state flow for two test cases representing typical finite wings at transonic conditions. Several grids of C-O topology and varying point densities are used. After a description of each code and test case, standards for determining code efficiency and accuracy are defined and applied to determine the relative performance of the two codes in predicting turbulent transonic wing flows. Comparisons of computed surface pressure distributions with experimental data are made. Author

A90-45910#**FINITE WING LIFT PREDICTION AT HIGH ANGLES OF ATTACK**

D. L. STAPLES and M. G. NAGATI (Wichita State University, KS) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 732-742. refs
(AIAA PAPER 90-3079) Copyright

Presented in this paper is an iterative method allowing the evaluation of the near-stall behavior of finite wings in incompressible flow. The technique utilizes three computational elements: A potential-flow panel code, a two-dimensional boundary-layer separation-wake modeler, and a data-interchange/graphics program. This approach was tested for an untwisted natural-laminar-flow wing of rectangular planform and exhibited excellent agreement with experiment for angles of attack up to maximum lift. Beyond the stall, the limitations are shown to be those of the two-dimensional separation analysis, which is not part of the present development. Author

A90-45911*# Eidetics International, Inc., Torrance, CA.**EFFECT OF LEADING EDGE ROUNDNESS ON A DELTA WING IN WING-ROCK MOTION**

T. TERRY NG and GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2.

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 743-753. refs
(Contract NAS2-12787)
(AIAA PAPER 90-3080) Copyright

The effect of wing leading-edge roundness on wing rock was investigated using flow visualization in a water tunnel. Eighty degree delta wing models were tested on free-to-roll and forced oscillation rigs. The onset of wing rock was delayed by increasing the roundness of the leading edges. The wing rock amplitude and frequency results suggested that damping was increased at lower angles of attack but reduced at higher angles of attack. Vortex lift-off and vortex breakdown, especially during dynamic situations, were strongly affected by the leading edge roundness. Different forms of wing rock motion could be sustained by combinations of vortex breakdown and vortex lift-off. Behaviors of the wing and vortex motions were explained by the influence of leading edge roundness on the separation location, vortex trajectory, and vortex breakdown. Author

A90-45912*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

AN UPWIND APPROACH TO UNSTEADY FLOWFIELD SIMULATION

CHRISTOPHER A. ATWOOD (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 754-773. refs
(Contract NCC2-540)
(AIAA PAPER 90-3100) Copyright

A numerical method to determine unsteady solutions of the laminar, perfect gas Navier-Stokes equations has been developed. The structured finite-volume, approximately factored implicit scheme uses Newton subiterations to obtain the spatially and temporally second-order accurate time history of the interaction of blast-waves with stationary targets. The inviscid flux is evaluated using either of two upwind techniques, while the viscous terms are computed by central differencing. Comparisons of numerical, analytical, and experimental results are made in two and three dimensions. The results show accurate wave speed resolution and nonoscillatory discontinuity capturing. Author

A90-45913#

NAVIER-STOKES SIMULATION OF UNSTEADY SUPERSONIC CAVITY FLOWFIELD WITH PASSIVE CONTROL

I. KIM and N. CHOKANI (North Carolina State University, Raleigh) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 774-782. Research supported by the North Carolina Board of Science and Technology. refs
(AIAA PAPER 90-3101) Copyright

A computational investigation of the supersonic turbulent flow past a two-dimensional rectangular cavity with passive venting is described. The effect of passive venting was included through the use of a porous surface over a vent chamber on the floor of the cavity. The passive venting was numerically simulated by the use of a linear form of the Darcy pressure law. The time-accurate solutions of the two-dimensional Reynolds-averaged Navier-Stokes equations were generated using the explicit MacCormack scheme. A two-layer algebraic eddy viscosity model, with a relaxation length modification, was used to model the Reynolds stresses. The capability of the numerical schemes is first demonstrated by the computations of an open and closed cavity without passive venting. The results of these computations also provide a reference case for the passive venting computations. The effect of passive venting on the closed cavity is then demonstrated and analyzed. Author

A90-45914#

A CHARACTERIZATION AND SEARCH TECHNIQUE FOR UNSTEADY FLOW CONTROL PROBLEMS

LAURA C. RODMAN (Nielsen Engineering and Research, Inc., Mountain View, CA) IN: AIAA Applied Aerodynamics Conference,

8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 783-791. refs
(Contract F49620-88-C-0006)
(AIAA PAPER 90-3102) Copyright

In this work, a characterization and search technique is described which can be used to optimize numerical boundary conditions for unsteady flow control problems. Certain selections of surface boundary conditions in a calculation can represent flow control techniques such as blowing or suction. A highly efficient optimization method is required to find desirable combinations of boundary conditions. The technique described here uses artificial intelligence methods which have the dual advantages of being highly efficient and being capable of providing additional information about the flow field being investigated. In an example of control of unsteady separation over a stalled airfoil, this method identified a region of strong dependence upon the boundary conditions as well as an optimum combination of boundary conditions. The region of strongest dependence provided a much more dramatic instance of flow control than the optimum region. Author

A90-45915*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

APPLICATION OF A STREAMWISE UPWIND ALGORITHM FOR UNSTEADY TRANSONIC COMPUTATIONS OVER OSCILLATING WINGS

SHIGERU OBAYASHI, GURU P. GURUSWAMY, and PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 792-808. refs
(AIAA PAPER 90-3103) Copyright

A new streamwise upwind algorithm has been derived to compute unsteady flows with a moving grid system and applied to compute flows over oscillating wings at transonic Mach numbers. Comparisons have been made between results obtained from this upwind algorithm, using both temporally nonconservative- and conservative-implicit methods, with the results obtained from a central-difference method, and also with experimental data. The results show (1) the efficiency and practicality of the temporally nonconservative implicit solver and (2) the robustness and accuracy of the upwind method for unsteady computations compared to the central-difference method. Author

A90-45917#

THE ROLE OF CFD APPLIED TO HIGH PERFORMANCE AIRCRAFT

W. H. DAVIS (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 818-828. refs
(AIAA PAPER 90-3071) Copyright

The creative use of CFD methods can address the flow physics of design problems and configuration concepts for which no design experience, data base, or test techniques exist. This approach can both yield critical design information and identify areas of high potential for future methodology development and applications programs. Specific cases, presented to support this CFD role, highlight 2D and 3D Navier-Stokes code simulations. The methods were capable of answering design problems for which subscale and flight testing were either impaired or impractical. Applications include (1) diagnostics leading to transonic buffet alleviation, (2) simulations extending the X-29 high-alpha envelope via nose jet control of forebody asymmetric vortical flow, and (3) a generic hypersonic forebody design sensitivity study. Author

A90-45918#

ON OPTIMAL SUPERSONIC/HYPERSONIC BODIES

W. H. MASON and JAEWOO LEE (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers.

Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 829-839. refs
(AIAA PAPER 90-3072) Copyright

A study of minimum drag body shapes was conducted over a Mach range from 3 to 12. Numerical results show that the power law bodies result in low drag shapes, where the $n = .69$ ($l/d = 3$) or $n = .70$ ($l/d = 5$) shapes have lower drag than the previous theoretical results ($n = .75$ or $n = .66$ depending on the particular form of the theory). To validate the results, a numerical analysis was made including viscous effects and the effect of gas model. None of these considerations altered the conclusions. The Hayes minimum drag body had a higher drag than the optimum power law body. Author

A90-45920* # National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EXPLORATORY WIND TUNNEL INVESTIGATION OF THE STABILITY AND CONTROL CHARACTERISTICS OF A THREE-SURFACE, FORWARD-SWEPT WING ADVANCED TURBOPROP MODEL

PAUL L. COE, JR. (NASA, Langley Research Center, Hampton, VA), JOHN N. PERKINS (North Carolina State University, Raleigh), and D. BRUCE OWENS IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 846-856. refs
(AIAA PAPER 90-3074) Copyright

The purpose of the present investigation was to parametrically study the stability and control characteristics of a forward-swept wing three-surface turboprop model through an extended angle of attack range, including the deep-stall region. As part of a joint research program between North Carolina State University and NASA Langley Research Center, a low-speed wind tunnel investigation was conducted with a three-surface, forward-swept wing, aft-mounted, twin-pusher propeller, model, representative of an advanced turboprop configuration. The tests were conducted in the NASA Langley 12-Foot Low-Speed Wind Tunnel. The model parameters varied in the test were horizontal tail location, canard size, sweep and location, and wing position. The model was equipped with air turbines, housed within the nacelles and driven by compressed air, to model turboprop power effects. A three-surface, forward-swept wing configuration that provided satisfactory static longitudinal and lateral/directional stability was identified. The three-surface configuration was found to have greater longitudinal control and increased center of gravity range relative to a conventional (two-surface) design. The test showed that power had a large favorable effect on stability and control about all three axis in the post-stall regime. Author

A90-45922#
ON THE DRAG REDUCTION OF BLUFF BODIES THROUGH MOMENTUM INJECTION

V. J. MODI, E. SHIH (British Columbia, University, Vancouver, Canada), and T. YOKOMIZO (Kanto Gakuin University, Kanazawa, Japan) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 866-874. refs
(AIAA PAPER 90-3076) Copyright

Effectiveness of the Moving Surface Boundary-Layer Control (MSBC) in increasing lift and/or reducing drag at a subcritical Reynolds number is studied, using a two-dimensional wedge shaped airfoil and a flat plate at high angles of attack, through an extensive wind tunnel test-program. Results suggest that injection of momentum, achieved here by introduction of bearing-mounted, motor-driven, hollow cylinders can significantly delay separation of the boundary-layer resulting in a narrow wake and the associated reduction in the pressure drag. Results show that both the cylinder surface velocity as well as the surface roughness have significant effect on the boundary-layer control. The wedge-airfoil showed an increase in $C(L)/C(D)$ from 2 to 80 while the flat plate at 90 deg showed a reduction in drag coefficient by around 75 deg. A flow visualization study, conducted in a closed-circuit water tunnel using

slit lighting and polyvinyl chloride tracer particles, complements the wind tunnel tests. It shows, rather dramatically, effectiveness of the moving surface boundary-layer control. Author

A90-45923#
AN EXPERIMENTAL STUDY OF A CLOSELY COUPLED TANDEM WING CONFIGURATION AT LOW REYNOLDS NUMBERS

DANIEL F. SCHARPF and THOMAS J. MUELLER (Notre Dame, University, IN) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 875-883. Research supported by the University of Notre Dame. refs
(Contract N00014-83-K-0239)
(AIAA PAPER 90-3094) Copyright

Experiments were conducted with two identical 6 arcsec chord Wortmann FX63-137 airfoils in closely coupled tandem configurations at a Reynolds number of 85,000. Direct measurement of lift, drag, and 1/4-chord pitching moment, as well as static pressure distributions were acquired for each airfoil. Flow visualization using kerosene smoke was performed to complement the experimental data. Results indicate a decrease in aerodynamic loads for a variety of configurations. The total drag reduction, and increased lift, resulted in a significant increase in the lift to drag ratio for a number of configurations at $Re(c) = 85,000$. Author

A90-45929* # National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ADAPTIVE GRID EMBEDDING FOR THE TWO-DIMENSIONAL EULER EQUATIONS

GARY P. WARREN (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 925-935. refs
(AIAA PAPER 90-3049) Copyright

A numerical algorithm is presented for solving the two-dimensional flux-split Euler equations using a multigrid method with adaptive grid embedding. The method uses an unstructured data set along with a system of pointers for communication on the irregularly shaped grid topologies. An explicit two-stage time advancement scheme is implemented. A multigrid algorithm is used to provide grid level communication and to accelerate the convergence of the solution to steady state. Results are presented for an NACA 0012 airfoil in a freestream with Mach numbers of 0.95 and 1.054. Excellent resolution of the shock structures is obtained with the adaptive grid embedding method with significantly fewer grid points than the comparable structured grid. Author

A90-45930#
AN UNSTRUCTURED-MESH EULER METHOD FOR MULTIELEMENT AIRFOIL GEOMETRIES

JOHN C. VASSBERG (Southern California, University, Los Angeles, CA) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 936-947. Research supported by the U.S. Navy. refs
(AIAA PAPER 90-3051) Copyright

An Euler method is presented which solves the transonic inviscid flow about multielement airfoil geometries. The grid generation first constructs a cloud of nodes about each element with the aid of the Karman-Trefftz conformal mapping, then triangulates the nodal set according to Delaunay properties. A procedure is introduced which further improves the 'quality' of the nodal set and the final unstructured mesh. The flow solver is based on techniques advocated by Jameson. Considerations regarding the mapping of the unstructured-mesh flow solver to parallel, vector processors are also discussed. Results of the present method for several airfoil configurations are compared with exact analytical solutions and industry-accepted CFD results. Author

A90-45932#

TRANSIENT AEROELASTIC COMPUTATIONS USING MULTIPLE MOVING FRAMES OF REFERENCE

C. FARHAT and T. Y. LIN (Colorado, University, Boulder) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 953-965. refs (Contract AF-AFOSR-89-0422) (AIAA PAPER 90-3053) Copyright

An economical approach for the simultaneous solution of the fluid/structure dynamic equations of equilibrium is presented. The structure is represented by a finite element model rather than modes. The governing equations of motion of the fluid are described in multiple moving frames of reference, each attached to a carefully selected node of the discretized structure. This results in the implicit generation of a structure-attached corotational fluid grid. For a rigid aeroelastic configuration, no single grid point needs to be explicitly moved or updated during the transient analysis, even when the structure undergoes large rigid-body motion. If the effect of small elastic deformations is included, the same corotational approach is used in conjunction with a fast scheme for updating the spatial metrics. The computational procedure is implemented within the ARC2D code and is validated with the two-dimensional unsteady flow computation and the transient flutter analysis of an NACA 0012 airfoil in transonic flow. It is also illustrated with the transient aeroelastic response of an infinite flexible wing-like structure resting on a Winkler type foundation. Author

A90-45933#

WAKE EFFECTS ON THE PREDICTION OF TRANSONIC VISCOUS FLOWS AROUND AIRFOILS WITH AN EULER/BOUNDARY LAYER INTERACTION APPROACH

D. P. COIRO, P. DE MATTEIS, and M. AMATO (Centro Italiano Ricerche Aerospaziali, Capua, Italy) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 11 p. refs (AIAA PAPER 90-3061) Copyright

A semi-inverse viscous/inviscid coupling technique for the calculation of compressible flows is presented. Euler equations in integral form are solved in the inviscid part and integral compressible boundary layer equations in inverse form are solved in the viscous one. Wake computation has been included for both displacement and curvature effects. Interaction is realized using the equivalent sources method. The technique has been applied to the calculation of the aerodynamic characteristics of airfoils both in subsonic and transonic regimes. The importance of body displacement, wake displacement and wake curvature viscous contributions has been evaluated and discussed. Different ways of computing the equivalent sources fluxes in the wake and the influence of the fixed wake dividing streamline shape have been investigated. Author

A90-45934#

DESIGN AND EXPERIMENTAL INVESTIGATION OF A LAMINAR HORIZONTAL TAIL

V. SCHMITT, J. RENEUX, and J. J. THIBERT (ONERA, Chatillon, France) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 11 p. refs (AIAA PAPER 90-3042) Copyright

A laminar horizontal tail has been designed for an executive aircraft with the aim of achieving a laminar flow region on both upper and lower surfaces of at least 50 percent during cruise. Experimental verifications including total force measurements, pressure distributions and transition visualizations by infrared thermography were accomplished in the S2MA wind tunnel of the ONERA test center at Modane. Tests were conducted in the transonic test section with solid walls on a 1:3 scaled model of the horizontal tail at flight Reynolds numbers in a large range of angles of attack and Mach numbers with free and fixed transition. Using these test conditions, different transition mechanisms are seen, transition due to laminar separation flow, and streamwise as well as crossflow instabilities. Results show good agreement with the predictions for pressure distributions and transition

locations. At the cruise lift level ($CL = 0.55$) the horizontal tail total drag reduction is as high as 11.5 percent. R.E.P.

A90-45935#

AN EVALUATION OF EULER SOLVERS FOR TRANSONIC FLOWFIELD COMPUTATIONS ON WING-FUSELAGE GEOMETRIES

S. AGRAWAL, R. B. LOWRIE, and S. F. CREASMAN (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 13 p. Research supported by McDonnell Douglas Independent Research and Development Program. refs (AIAA PAPER 90-3015) Copyright

Three different Euler solvers, which use different formulations, are evaluated for transonic flowfield computations on wing-fuselage configurations. Explicit finite-volume central-difference, implicit finite-volume upwind, and non-conservative upwind are the schemes upon which the formulations of the solvers are based. Solutions are obtained on two configurations using the three solvers, and are evaluated for the overall solution accuracy and the rate of convergence. Results predicted by the three methods are similar, except for some differences in coarse grid regions and near shock locations. The upwind finite-volume scheme is found to predict shock waves with the best resolution, and for a given grid its predictions agree best with the test data. Also, changes in its solution with improved grid resolution are found to be smaller in comparison to those computed by the other two methods. The best level and rate of convergence for these cases are found with the central-difference method, using Runge-Kutta time-stepping and full multigrid schemes. Author

A90-45936*# Vigyan Research Associates, Inc., Hampton, VA. NUMERICAL STUDY OF VORTICAL FLOW OVER A SIDESLIPPING DELTA WING

C.-H. HSU (Vigyan, Inc., Hampton, VA) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 7 p. refs (Contract NAS1-18585) (AIAA PAPER 90-3001)

The three-dimensional vortical viscous flow past a sideslipping delta wing at a high angle of attack is numerically investigated. A computational method for calculating low-speed viscous flowfields is developed. The time-iterative method uses an implicit upwind-relaxation finite-difference algorithm with a nonsingular eigensystem to solve the preconditioned, three-dimensional, incompressible Navier-Stokes equations in curvilinear coordinates. An algebraic turbulence model is implemented to account for the eddy viscosity. The technique of local time stepping is incorporated to accelerate the rate of convergence to a steady-state solution. Computed results are compared with experimental data. Author

A90-45937#

OUTFLOW BOUNDARY CONDITIONS USING DUHAMEL'S EQUATION

DAVID NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 8 p. refs (Contract F49620-88-C-0006) (AIAA PAPER 90-3014) Copyright

An alternative to nonreflecting boundary conditions is proposed and is applied to unsteady transonic potential flow about an airfoil. This method is based on a time-linearized version of the equations, but a representation of all other nonlinearities is kept in the model. It is determined that satisfactory results could be obtained with a downstream boundary at 2 percent of the extent necessary for conventional nonreflecting boundary conditions. It is concluded that computational domains could be reduced if this methodology is applied. In principle, there is no difficulty in applying these ideas to more complex equations, such as the Navier-Stokes or Euler equations. R.E.P.

A90-46358

LOW REYNOLDS NUMBER AERODYNAMICS; PROCEEDINGS OF THE CONFERENCE, UNIVERSITY OF NOTRE DAME, IN, JUNE 5-7, 1989

THOMAS J. MUELLER, ED. (Notre Dame, University, IN) Conference sponsored by the University of Notre Dame. Berlin and New York, Springer-Verlag (Lecture Notes in Engineering, Volume 54), 1989, 451 p. For individual items see A90-46359 to A90-46389.

Copyright

The conference presents papers on the analysis and design system for low Reynolds number airfoils, the prediction of aerodynamic performance of airfoils in low Reynolds number flows, and a fast method for the computation of airfoil characteristics. Consideration is also given to the study of low-Reynolds number separated flow past the Wortmann FX 63-137 airfoil, a method for determining the performance of low-Reynolds-number airfoils under off-design unsteady freestream conditions, and the computation of viscous unsteady compressible flow about profiles. The design of a low Reynolds number RPV is studied as well as vortex lock-on and flow control in bluff body near-wakes. K.K.

A90-46359

XFOIL - AN ANALYSIS AND DESIGN SYSTEM FOR LOW REYNOLDS NUMBER AIRFOILS

MARK DRELA (MIT, Cambridge, MA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 1-12. Research supported by MIT and NSF. refs

Copyright

Calculation procedures for viscous/inviscid analysis and mixed-inverse design of subcritical airfoils are presented. An inviscid linear-vorticity panel method with a Karman-Tsien compressibility correction is developed for direct and mixed-inverse modes. Source distributions superimposed on the airfoil and wake permit modeling of viscous layer influence on the potential flow. Both laminar and turbulent layers are treated, with an e^{-9} -type amplification formulation determining the transition point. The boundary layer and transition equations are solved simultaneously with the inviscid flowfield by a global Newton method. The procedure is especially suitable for rapid analysis of low Reynolds number airfoil flows with transitional separation bubbles. Author

A90-46360

PREDICTION OF AERODYNAMIC PERFORMANCE OF AIRFOILS IN LOW REYNOLDS NUMBER FLOWS

DOMENICO P. COIRO (Centro Italiano Ricerche Aerospaziali, Capua, Italy) and CARLO DE NICOLA (Napoli, Università, Naples, Italy) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 13-23. Previously announced in STAR as N90-23360. refs

Copyright

A viscous/inviscid interaction procedure for the solution of incompressible flowfields with large laminar separated regions is presented, based on the approach previously followed for the prediction of the performances of airfoils up to stall conditions. The extension of the interaction procedure to take into account the existence of laminar separation bubbles is described, with an eye toward the question of the numerical determination of the transition. The application of the computational procedure for two airfoils widely investigated experimentally at low Reynolds number is discussed; numerical results show the reliability of the method in these conditions. A critical analysis of the solutions indicates the guidelines for the future improvements of the method.

Author

A90-46361

A FAST METHOD FOR COMPUTATION OF AIRFOIL CHARACTERISTICS

ARILD BERTELDRUD (High Technology Corp., Hampton, VA) IN: Low Reynolds number aerodynamics; Proceedings of the

Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 24-38. refs

Copyright

A simple method for computation of the flow on airfoils has been developed to help in the development of suitable profiles for turbulence manipulation. Typically these will have chord Reynolds numbers of 300,000 or less, be located in a high subsonic or transonic Mach number boundary layer close to a wall. The analysis does not require a good prediction of maximum lift, but instead must be able to describe flow properties and drag adequately within a CL-range. Since a large number of parameters are involved, and since the turbulence manipulation to a large extent depends on the dynamics of the flow on and behind the profiles, it was necessary to establish a code that was direct, fast, and allowed computation of typical characteristics in a matter of minutes on a minicomputer or a personal computer. Author

A90-46362

LOW REYNOLDS NUMBER AIRFOIL DESIGN AND WIND TUNNEL TESTING AT PRINCETON UNIVERSITY

J. F. DONOVAN (Princeton University, NJ) and M. S. SELIG IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 39-57. refs

Copyright

The development of efficient low Reynolds number airfoils is discussed. The tests were carried out in the Princeton University 3 by 4 ft Smoke Tunnel. Measurements obtained in other facilities are used as a basis of comparison for the lift and drag obtained in the present study. It was found that a long region of roughly constant adverse pressure gradient on the upper surface achieved a lower drag than the more conventional laminar flow-type velocity distribution. K.K.

A90-46363

STUDY OF LOW-REYNOLDS NUMBER SEPARATED FLOW PAST THE WORTMANN FX 63-137 AIRFOIL

K. N. GHIA, G. OSSWALD, and U. GHIA (Cincinnati, University, OH) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 58-69. refs

(Contract AF-AFOSR-87-0074)

Copyright

Flow past a Wortmann FX 63-137 airfoil is analyzed using the unsteady Navier-Stokes analysis developed earlier by the authors. The analysis is formulated using conservation form of the governing NS equations in terms of stream function, and vorticity, in generalized coordinates. A Schwarz-Christoffel mapping technique is developed to provide surface-oriented coordinates for the Wortmann FX 63-137 airfoil. Suitable one-dimensional clustering transformations are used, not only to obtain a bounded computational domain, but, also to resolve the dominant length scales of the problem. Direct numerical simulation methodology is used to obtain flow results at $Re = 1000$ with $\alpha-f$ varying from -5 to 10 deg; simulations are also performed at $\alpha-f = 0$ deg with $Re = 10,000$ and $100,000$ without any turbulence model. Author

A90-46364

AN INTERACTIVE BOUNDARY-LAYER STABILITY-TRANSITION APPROACH FOR LOW REYNOLDS-NUMBER AIRFOILS

TUNCER CEBECI (California State University, Long Beach) and MARGARET MCILVAINE IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 70-81. refs

Copyright

An interactive boundary-layer stability-transition approach for predicting the performance characteristics of airfoils at low Reynolds numbers is described and evaluated in terms of experimental data. The interactive boundary-layer procedure makes use of a panel method and an inverse boundary-layer scheme in

which the Reynolds stress term is modeled by an algebraic eddy-viscosity formulation. The governing equations are solved in inverse mode by a two-point finite-difference method. The procedure also makes use of the $\epsilon(n)$ -method to determine the location of transition. The turbulence model employs an extended version of the intermittency expression in the Cebeci and Smith eddy-viscosity model. Author

A90-46365

THE INSTABILITY OF TWO-DIMENSIONAL LAMINAR SEPARATION

LAURA L. PAULEY (Pennsylvania State University, University Park), PARVIZ MOIN, and WILLIAM C. REYNOLDS (Stanford University, CA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 82-92. refs
(Contract N00014-84-K-0232)

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The separation of a two-dimensional laminar boundary layer under the influence of an external adverse pressure gradient was studied. The unsteady incompressible Navier-Stokes equations were solved using a fractional-timestep method. It was found that strong pressure gradients created periodic shedding from the separation. The frequency of shedding was influenced by the Reynolds number but not by the strength of the pressure gradient. The vortex shedding was due to the inviscid instability of the separated laminar shear layer. When the results were time-averaged, the unsteady separation produced a pressure gradient and streamline pattern similar to those found in laminar separation experiments. This suggests that the rapid reattachment found in experiments may be due to large-scale laminar structures. Author

A90-46366

BURSTING IN SEPARATING FLOW AND IN TRANSITION

FRANK T. SMITH (University College, London, England) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 93-103. Research supported by the Royal Aircraft Establishment, SERC, University of London, and United Technologies Independent Research Program. refs
Copyright

Three recent developments in the theory and associated computations of separating and transitional boundary layers are addressed. The three developments, which are very much interrelated, concern the following: a reversed-flow breakdown in the solution of the steady interacting boundary-layer equations; a finite-time breakup possible in any unsteady interactive boundary layer; and the absence of large-scale separation in turbulent flow. The aerodynamic implications for stall, intermittency, transition and turbulence effects are also emphasized. Author

A90-46367

A REVIEW OF LOW REYNOLDS NUMBER AERODYNAMIC RESEARCH AT THE UNIVERSITY OF GLASGOW

R. A. MCD. GALBRAITH and F. N. COTON (Glasgow, University, Scotland) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 104-114. refs
Copyright

The paper gives the succinct overview of the low Reynolds number work carried out at Glasgow University, together with some of the salient and interesting results observed. The work covers both experimental and computational aspects, with the emphasis being on a practical knowledge of aerofoil performance and prediction. The measured performance of four aerofoils is presented along with a discussion of specific aspects of the flow observed. A low-speed performance prediction scheme is outlined and its range of applicability highlighted by some particular examples. Finally, the main conclusions of the research program are discussed. Author

A90-46368

EXPERIMENTAL AERODYNAMIC CHARACTERISTICS OF THE AIRFOILS LA 5055 AND DU 86-084/18 AT LOW REYNOLDS NUMBERS

L. M. M. BOERMANS, F. J. DONKER DUYVIS, J. L. VAN INGEN, and W. A. TIMMER (Delft, Technische Universiteit, Netherlands) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 115-130. refs
Copyright

The performance characteristics of an Eppler 387 airfoil using both the direct (force) and indirect (pressure) measurement technique were obtained at Reynolds numbers in the range of 60,000 to 460,000 in the Langley Low Turbulence Pressure Tunnel. The lift and pitching-moment data obtained from the balance measurements are found to be in good agreement with those obtained from the integration of the pressure data. A comparison was made between the drag data obtained from the balance measurements and the results obtained using the wake traverse method. Good agreement was found for Reynolds numbers greater than 100,000 and angles of attack of 0, 2, and 4 deg. K.K.

A90-46369* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PERFORMANCE MEASUREMENTS OF AN AIRFOIL AT LOW REYNOLDS NUMBERS

ROBERT J. MCGHEE and BETTY S. WALKER (NASA, Langley Research Center, Hampton, VA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 131-145. refs

Copyright

Performance characteristics of an Eppler 387 airfoil using both direct (force) and indirect (pressure) measurement techniques have been obtained at Reynolds numbers from 60,000 to 460,000 in the Langley Low-Turbulence Pressure Tunnel. Lift, drag, and pitching-moment data were obtained from two internally-mounted strain-gage balances specifically designed for small aerodynamic loads. Comparisons of these results with data from a pressure model of an Eppler 387 airfoil are included. Drag data for both models using the wake traverse method are compared with the balance data. Oil flow visualization and surface mounted hot-film sensors were used to determine laminar-separation and turbulent-reattachment locations. Problems associated with obtaining accurate wind-tunnel data at low Reynolds numbers are discussed. Author

A90-46370* Analytical Services and Materials, Inc., Hampton, VA.

CORRELATION OF THEORY TO WIND-TUNNEL DATA AT REYNOLDS NUMBERS BELOW 500,000

RAQUEL EVANGELISTA (Analytical Services and Materials, Inc., Hampton, VA), ROBERT J. MCGHEE, and BETTY S. WALKER (NASA, Langley Research Center, Hampton, VA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 146-160. refs
Copyright

This paper presents results obtained from two airfoil analysis methods compared with previously published wind tunnel test data at chord Reynolds numbers below 500,000. The analysis methods are from the Eppler-Somers airfoil design/analysis code and from ISES, the Drela-Giles Airfoil design/analysis code. The experimental data are from recent tests of the Eppler 387 airfoil in the NASA Langley Low Turbulence Pressure Tunnel. For R not less than 200,000, lift and pitching moment predictions from both theories compare well with experiment. Drag predictions from both theories also agree with experiment, although to different degrees. However, most of the drag predictions from the Eppler-Somers code are accompanied with separation bubble warnings which indicate that the drag predictions are too low. With the Drela-Giles code, there is a large discrepancy between the computed and experimental

pressure distributions in cases with laminar separation bubbles, although the drag polar predictions are similar in trend to experiment. Author

A90-46371

AN EXPERIMENTAL STUDY OF LOW-SPEED SINGLE-SURFACE AIRFOILS WITH FAIRED LEADING EDGES

JAMES D. DELAURIER (Toronto, University, Downsview, Canada) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 161-173. refs Copyright

The development of a large model ornithopter required the design of an aerodynamically efficient wing with torsional compliance. A solution for this was to use an essentially single-surface airfoil with a faired leading edge. This paper describes wind-tunnel tests on various candidate airfoils, with the goal of attaining the largest angle-of-attack range for attached flow. Also tested were several 'benchmark' sections, such as single-surface airfoils with sharp leading edges and an Eppler 193 double-surface airfoil. The results showed no candidate as good as the Eppler design, but very acceptable performance was obtained from a section with a streamlined leading-edge fairing on the upper side of a 5-percent circular arc. Author

A90-46372* Pennsylvania State Univ., University Park.

A COMPUTATIONALLY EFFICIENT MODELLING OF LAMINAR SEPARATION BUBBLES

PAOLO DINI and MARK D. MAUGHMER (Pennsylvania State University, University Park) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 174-188. Previously announced in STAR as N90-12872. refs (Contract NAG1-778) Copyright

In order to predict the aerodynamic characteristics of airfoils operating at low Reynolds numbers, it is necessary to accurately account for the effects of laminar (transitional) separation bubbles. Generally, the greatest difficulty comes about when attempting to determine the increase in profile drag that results from the presence of separation bubbles. While a number of empirically based separation bubble models have been introduced in the past, the majority assume that the bubble development is fully predictable from upstream conditions. One way of accounting for laminar separation bubbles in airfoil design is the bubble analog used in the design and analysis program of Eppler and Somers. A locally interactive separation bubble model was developed and incorporated into the Eppler and Somers program. Although unable to account for strong interactions such as the large reduction in suction peak sometimes caused by leading edge bubbles, it is able to predict the increase in drag and the local alteration of the airfoil pressure distribution that is caused by bubbles occurring in the operational range which is of most interest. Author

A90-46374

UNSTEADY AERODYNAMICS OF WORTMANN FX63-137 AIRFOIL AT LOW REYNOLDS NUMBERS

ANDREW M. WO and EUGENE E. COVERT (MIT, Cambridge, MA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 206-217. refs (Contract N00014-85-K-0513) Copyright

Unsteady pressure data are discussed for a two-dimensional Wortmann FX63-137 airfoil at Reynolds numbers 125,000 and 400,000, $\alpha = 0$ deg, and over a range of reduced frequencies, k , from 0.15 to 6.4. Unsteady boundary layer data near the region of laminar separation are also presented for $Re = 125,000$, $k = 0.15$ and 2.0. Surface pressure data show that the unsteady excitation imposed interacts most actively in the transition region with large amplitude and higher harmonics. Unsteady boundary layer results in the region of laminar separation reveal that the time mean unsteady velocity profile for both reduced frequencies

tested are quite similar. The ensemble averaged profiles for $k = 0.15$ suggest that the unsteady boundary layer tends to be more attached when the free stream velocity is minimum. Data show that this effect is less pronounced at $k = 2.0$. Author

A90-46375

A METHOD TO DETERMINE THE PERFORMANCE OF LOW-REYNOLDS-NUMBER AIRFOILS UNDER OFF-DESIGN UNSTEADY FREESTREAM CONDITIONS

HELEN L. REED and BETH A. TOPPEL (Arizona State University, Tempe) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 218-230. refs (Contract N00014-86-K-0066) Copyright

A procedure is described to analyze the boundary layer on airfoils experiencing unsteady flight conditions and to predict the changes in the performance characteristics during off-design. The method predicts the flow in the boundary-layer region near the separation bubble using the incompressible Navier-Stokes equations with boundary conditions from inviscid and laminar boundary-layer solutions. The rate at which the separation bubble develops and decays is of primary interest in this study. Unsteady surface-pressure-coefficient distributions and velocity profiles are presented. Immediate-future work will include application of this technique to two state-of-the-art airfoils, the ASM-LRN-010 and Wortmann FX63-137 airfoil sections with chord Reynolds numbers of 250,000 and 500,000 and operating under light dynamic stall conditions. Author

A90-46376

CONTROL OF LOW-REYNOLDS-NUMBER AIRFOILS - A REVIEW

MOHAMED GAD-EL-HAK (Notre Dame, University, IN) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 246-270. refs Copyright

The present article is an overview of passive and active techniques used to control a low-Reynolds-number boundary layer to achieve an improved performance. A unified view based on a vorticity framework is presented to explain many of the available or contemplated control methods. Among the control techniques to be considered are wall suction/injection, shaping, heat transfer through the surface, introduction of a foreign substance into the boundary layer, fixed or moving geometric modifications, and turbulence manipulation. Among the practical considerations that are reviewed for these devices are their cost of construction and operation, complexity, and potential trade-off or penalties associated with their use. Author

A90-46377* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THE LOW FREQUENCY OSCILLATION IN THE FLOW OVER A NACA0012 AIRFOIL WITH AN 'ICED' LEADING EDGE

K. B. M. Q. ZAMAN and M. G. POTAPCZUK (NASA, Lewis Research Center, Cleveland, OH) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 271-282. Previously announced in STAR as N89-23417. refs Copyright

The unusually low frequency oscillation in the wake of an airfoil is explored experimentally as well as computationally for a NACA0012 airfoil with a glaze ice accretion at the leading edge. Experimentally, flow oscillations were observed at low frequencies that correspond to a Strouhal number of about 0.02. This occurred in the angle of attack range of 8 to 9 deg, near the onset of static stall for this airfoil. With a Navier-Stokes computation, limit-cycle oscillations in the flow and in the aerodynamic forces were also observed at low Strouhal numbers. However, the occurrence of the oscillation is found to depend on the turbulence model in use as well as the Reynolds number. Author

A90-46378* Vanderbilt Univ., Nashville, TN.
**DETACHMENT OF TURBULENT BOUNDARY LAYERS WITH
 VARYING FREE-STREAM TURBULENCE AND LOWER
 REYNOLDS NUMBERS**

J. LEITH POTTER, R. JOEL BARNETT, COSTAS E. KOUKOUSAKIS, and CARL E. FISHER (Vanderbilt University, Nashville, TN) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 283-294. refs (Contract NAG1-483)

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Experiments conducted to determine if free-stream turbulence scale affects detachment of turbulent boundary layers are described. Hot-wire anemometry, liquid-film visualization, a Preston tube, and static pressure measurements were used to study flow over a two-dimensional airfoil in a subsonic wind tunnel. The free-stream turbulence intensity and scale were found to spread to the entire turbulent boundary layer. However, the effect decreased upon approaching the airfoil surface. K.K.

A90-46379* High Technology Corp., Hampton, VA.
**WIND-TUNNEL INVESTIGATIONS OF WINGS WITH
 SERRATED SHARP TRAILING EDGES**

P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), C. P. VAN DAM (California, University, Davis), B. J. HOLMES, and F. G. HOWARD (NASA, Langley Research Center, Hampton, VA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 295-313. refs (Contract NAG1-345; NAS1-18240)

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Exploratory wind-tunnel force measurements are presented for two wing geometries with small-scale planar and nonplanar serrated trailing-edge devices (chord-Reynolds numbers ranged from 1.0 - 3.7 x 10 to the 6th). The planar serrated trailing-edge extensions reduced the drag at conditions when trailing-edge separation occurred at low angles of attack. The introduction of serrations reduced or eliminated the drag penalty due to the small (1-2 percent of the chord length) nonplanar trailing-edge flaps, while maintaining the effects of increase in camber. The presence of streamwise vortices immediately downstream of the serrated trailing edges is believed to have favorably affected the boundary-layer flow approaching the trailing edge and the near-wake development, resulting in reduced pressure drag. Author

A90-46380
**LOW REYNOLDS NUMBER AIRFOIL DESIGN FOR SUBSONIC
 COMPRESSIBLE FLOW**

ROBERT H. LIEBECK (Douglas Aircraft Co., Long Beach, CA) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 314-330. Research supported by USAF.

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An airfoil design study has been conducted to examine the capability of providing high lift in the Reynolds number range of 0.5 to 5.0 million at Mach 0.4. This relatively moderate Mach number produces significant compressibility effects when design lift coefficients in excess of 1.5 are desired. Four example airfoils have been developed with various thickness ratios and degrees of aft loading. The MIT ISES airfoil analysis code has been used to theoretically predict performance including drag rise characteristics. In addition, as a calibration, the ISES code was applied to airfoils where wind tunnel results were available, and agreement with the data was very good. Author

A90-46382
**COMPRESSIBLE NAVIER-STOKES SOLUTIONS OVER LOW
 REYNOLDS NUMBER AIRFOILS**

ZUHEYR ALSALIHI (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN,

June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 343-357. refs

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Time-averaged two-dimensional compressible Navier-Stokes equations are solved to numerically model unsteady laminar or turbulent, compressible or incompressible flow at low Reynolds numbers over a Wortmann FX63-137 airfoil. The hyperbolic grid generation technique is used to generate C-type grids. Results are presented for test cases with free-stream Reynolds numbers of 600,000 to 700,000 and free-stream Mach numbers of 0.01 to 0.5. K.K.

A90-46383
**SHOCK/TURBULENT BOUNDARY LAYER INTERACTION IN
 LOW REYNOLDS NUMBER SUPERCRITICAL FLOWS**

G. R. INGER (Iowa State University of Science and Technology, Ames) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 358-368. refs

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This paper describes a theoretical study of the effects of Reynolds number on nonseparating transonic shock/turbulent boundary layer interaction, with emphasis on the low Reynolds number regime (Re-delta between 1000 and 1,000,000). A unique nonasymptotic triple deck theory of the interaction is used which is specifically designed to treat this regime, where classical high Reynolds number asymptotic theory is inapplicable. The results of a comprehensive parametric study are given showing how the local interactive pressure, displacement thickness, and skin friction distributions each depend on Reynolds number and how and why this dependence differs markedly from the predictions of high-Re asymptotics. For example, under conditions of interest to the low Reynolds number aerodynamicist, it is shown that the size of the interaction zone does not even approximately scale with the local boundary layer thickness, but instead follows its own interactive scaling law inherent to the compressible viscous flow involved. Author

A90-46384
**SUMMARY OF EXPERIMENTAL TESTING OF A TRANSONIC
 LOW REYNOLDS NUMBER AIRFOIL**

PEGGY L. TOOT (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 369-380. refs

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The development on the part of the U.S. Navy of small transonic-speed unmanned aircraft for electronic warfare missions is discussed. Experimental testing carried out to establish a transonic low Reynolds number two-dimensional airfoil data base for verifying computational analysis is described. The chord Reynolds number region of interest was shown to be below 1,000,000 at speeds of 0.7 to 1.2 Mach. The biconvex circular-arc airfoil was modeled for these studies. K.K.

A90-46486
**EFFECT OF THE NONUNIFORMITY OF EXTERNAL
 SUPERSONIC FLOW AND NOZZLE DEFLECTION ANGLE ON
 THE BASE PRESSURE BEHIND AN AXISYMMETRIC BODY
 WITH A SINGLE SUPERSONIC JET [VLIANIE
 NERAVNOMERNOSTI VNESHNEGO SVERKHZVUKOVOGO
 POTOKA I UGLA OTKLONENIIA SOPLA NA DONNOE
 DAVLENIE ZA OSESIMMETRICHNYM TELOM S ODINOCHNOI
 SVERKHZVUKOVOI STRUEI]**

I. S. BELOTSERKOVETS, V. I. TIMOSHENKO, and L. M. FILIPPOVSKAIA (Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 34-36. In Russian. refs

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The effect of external flow nonuniformity and nozzle deflection angle (relative to the axis of symmetry) on the base pressure is estimated using the separating flow line method. It is shown, in particular, that the base pressure increases with the free-stream Mach number. Changes in angle of attack and nozzle deflection

angle affect the base pressure via a number of factors. The combined effect of these factors leads to a decrease in the base pressure with increasing angle of attack and nozzle deflection angle. V.L.

A90-46487

NUMERICAL CALCULATION OF TURBULENT SEPARATED FLOWS IN AN ABRUPTLY EXPANDING CHANNEL [CHISLENNYI RASCHET TURBULENTNYKH OTRYVNYKH TECHENII V KANALE PRI VNEZAPNOM RASSHIRENII]

V. K. BULGAKOV, A. M. LIPANOV, and A. M. ROSLOV
Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 37-40.
In Russian. refs

Copyright

The paper deals with the problem of the numerical modeling of separated turbulent flows of a viscous compressible gas in a channel with an abruptly varying cross section. In particular, sonic flow of a gas in a sudden expansion is calculated using the averaged Reynolds equations. The validity of the approach adopted here is supported by comparisons between numerical results and experimental data. V.L.

A90-46500

MODELING OF THE BUFFETING OF FLIGHT VEHICLES [K MODELIROVANIU BAFINGA LETATEL'NOGO APPARATA]

V. I. MOROZOV, V. M. ONISHCHENKO, and A. T. PONOMAREV
Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 84-87.
In Russian.

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A method for developing a mathematical model of aeroelasticity for solving problems concerning the loading and deformation of flight vehicles under conditions of buffeting is presented. The approach used here combines numerical methods of nonlinear aerodynamics with a mathematical model of aeroelasticity. Additional nonlinear external forces acting on the individual components of the flight vehicle from the wake are calculated independently (without allowance for aerodynamic interference) using nonlinear aerodynamics and linear aeroelasticity equations. V.L.

A90-46502

CALCULATION OF NONSTATIONARY FORCES IN A THREE-ROW COMPRESSOR CASCADE [RASCHET NESTATSIONARNYKH SIL V TREKHRIADNOI KOMPRESSORNOI RESHETKE PROFILEI]

V. A. VANIN
Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 90-92. In Russian.

Copyright

Nonstationary processes associated with multistage three-row compressor cascades are investigated analytically using a system of Euler equations, which is approximated by Godunov's difference scheme. As an example, calculations are carried out for a typical three-row compressor stage with a blade ratio of 5:3:4. An analysis of the results obtained shows that load nonstationarity can be reduced not only through the traditional gap increase but also through a combination of gap reduction and turning of the guide vane. V.L.

A90-46503

A PROBLEM IN THE THEORY OF OPTIMAL AERODYNAMIC SHAPES [OB ODNOI ZADACHE TEORII OPTIMAL'NYKH AERODINAMICHESKIKH FORM]

K. G. GARAEV
Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 92, 93. In Russian.

Copyright

The paper is concerned with axial flow of a compressible gas past a rotating body. In particular, attention is given to the variational problem of finding, among smooth extrema $R(x)$, an extremum which would yield the minimum value of the antitorque moment. The problem is solved analytically using Euler-Lagrange-Ostrogradskii equations. V.L.

A90-46534

LOCAL CONVERGENCE OF THE SOLUTION IN THE DISCRETE VORTEX METHOD [O LOKAL'NOI SKHODIMOSTI RESHENIIA V METODE DISKRETNYYKH VIKHREI]

G. G. SUDAKOV
TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 15-25. In Russian.

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The paper is concerned with the local convergence of a numerical solution to the singular integral equation of an infinite-span wing obtained by the discrete vortex method using a grid with a pitch tending to zero. Particular attention is given to the solution convergence characteristics in the vicinity of singular lines (leading and trailing edges and the discontinuity line of grid parameters and boundary conditions). The mathematical formalism developed here makes it possible to establish the convergence or nonconvergence of the numerical solution in the vicinity of the singular line, provides a way to transform a nonconverging solution to a converging one, and allows the estimation of the effect of the solution in the local region on the solution in the principal region. V.L.

A90-46536

CALCULATION OF THE HEAT FLUX AT A THREE-DIMENSIONAL CRITICAL POINT IN SUPERSONIC FLOW PAST A BODY [RASCHET TEPOVOGO POTOKA V PROSTRANSTVENNOI KRITICHESKOI TOCHKE PRI SVERKHZVUKOVOM OBTEKANII TELA]

A. L. ANKUDINOV
TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 37-45. In Russian. refs

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The problem of heat flux calculation at a three-dimensional critical point in the theory of a hypersonic thin viscous layer leads to a boundary value problem for a system of differential equations with an 'extra' boundary condition. It is shown that the thin layer model makes it possible to reduce this problem to that of solving an algorithmically simpler, strictly boundary value problem without an 'extra' condition. Examples of thin viscous layer calculations for a three-dimensional critical point are presented. V.L.

A90-46538

A STUDY OF GAS FLOW IN HYPERSONIC NOZZLES AT LARGE REYNOLDS NUMBERS USING SIMPLIFIED NAVIER-STOKES EQUATIONS [ISSLEDOVANIE TECHENIIA GAZA V GIPERZVUKOVYKH SOPLAKH PRI BOL'SHIKH CHISLAKH REINOL'DSA NA OSNOVE UPROSHCHENNYKH URAVNENII NAV'E-STOKSA]

V. I. BEZMENOV, A. P. BYRKIN, P. I. GORENBUKH, V. A. SABEL'NIKOV, T. A. TIMOFEEVA et al.
TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 53-61. In Russian. refs

Copyright

Results of numerical calculations of turbulent flows of helium and air in conical and profiled hypersonic nozzles based on simplified Navier-Stokes equations and a one-parameter turbulence model are presented, as are results of an experimental study of these flows at Reynolds numbers of $(0.1-1.4) \times 10$ to the 7th. Satisfactory agreement is obtained between the calculated and experimentally determined Mach number fields in the nonviscous flow core. The approach proposed here can be used for predicting Mach number fields in the test section of hypersonic wind tunnels. V.L.

A90-46542

CONSTRUCTION OF WING PROFILES IN SUBSONIC GAS FLOW BY THE METHOD OF QUASI-SOLUTIONS FOR INVERSE BOUNDARY VALUE PROBLEMS [POSTROENIE KRYLOVYKH PROFILEI V DOZVUKOVOM POTOKE GAZA METODOM KVAZIRESHENII OBRATNYKH KRAEVYKH ZADACH]

N. B. IL'INSKII, A. V. POTASHEV, and D. A. FOKIN
TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 98-101. In Russian. refs

Copyright

Based on the Chaplygin gas model, a method is developed for satisfying the solvability condition for the problem of wing profile construction based on the specified velocity distribution on its surface in the path of a plane steady-state subsonic flow of an ideal gas. Results of a computational experiment are presented to demonstrate the validity of the method. The effect of compressibility on the profile shape is discussed. V.L.

A90-46545

WALL PRESSURE PULSATION SPECTRA AHEAD OF INTERNAL CORNERS [SPEKTRY PRISTENOCHNYKH PUL'SATSII DAVLENIIA PERED VNUTRENNIMI UGLAMI]

V. N. BIBKO, B. M. EFIMTSOV, and V. B. KUZNETSOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 112-118. In Russian. refs

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The paper generalizes results of experimental studies of the spectra of turbulent wall pressure pulsations ahead of two-dimensional internal corners (10-60 deg) for free-stream Mach 2.0-4.0 in the Reynolds number range from 3.2×10 to the 4th to 2.8×10 to the 5th. Conditions for the similarity of pressure pulsation spectra are determined. Expressions are obtained which relate pressure pulsation spectra to the similarity parameters. V.L.

A90-46548

APPLICATION OF THE INVERSE METHOD OF THREE-DIMENSIONAL BOUNDARY LAYER ANALYSIS TO THE PROBLEM OF FLOW PAST A WING WITH ALLOWANCE FOR THE EFFECT OF VISCOSITY [PRIMENENIE OBRATNOGO METODA RASCHETA TREKHMERNOGO POGRANICHNOGO SLOIA K ZADACHE OBTEKANIIA KRYLA S UCHEMOM VLIIANIIA VIAZKOSTI]

O. V. KARAS' and V. E. KOVALEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 1-11. In Russian. refs

An inverse method has been developed for calculating three-dimensional compressible laminar and turbulent boundary layers using a numerical predictor-corrector scheme and Keller's scheme. Based on a semiinverse method of viscous-nonviscous interaction analysis, an algorithm is developed for calculating flow past a wing at transonic flight velocities with allowance for the effect of viscosity, including thin separation zones. An example of calculations for isolated wings are presented. V.L.

A90-46550

INTERFERENCE BETWEEN A VORTEX FILAMENT AND SHOCK WAVES IN FREE FLOW AND IN NONISOBARIC JETS [INTERFERENTSIIA VIKHREVOGO SHNURA SO SKACHKAMI UPLOTNENIIA V SVOBODNOM POTOKE I NEIZOBARICHESKIKH STRUIAKH]

G. F. GLOTOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 21-32. In Russian. refs

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The interaction between a vortex filament generated by a wing cantilever at angles of attack of 5-20 deg and shock waves in free stream (Mach 1.8-3.5) in an underexpanded jet (Mach 1.0) was investigated experimentally in the relative pressure range 1.5-7. It is shown that the interaction between the vortex filament and a central shock wave in the jet leads to the formation of a freely suspended recirculation zone. Vortex breakdown limits are determined for a jet, a convergent nozzle, and supersonic flow at conical shock waves of maximum intensity. V.L.

A90-46551

SOME CHARACTERISTICS OF INTERFERENCE BETWEEN SHOCK WAVES AND THE AERODYNAMIC WAKE BEHIND A BODY [NEKOTORYE OSOBENNOSTI INTERFERENTSII SKACHKOV UPLOTNENIIA S AERODINAMICHESKIM SLEDOM ZA TELOM]

A. K. IVANIUSHKIN, I. V. KOROTKOV, and A. V. NIKOLAEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 33-42. In Russian. refs

Copyright

A study was made of the conditions of formation of stagnation zones with free boundaries during the interaction of a shock wave with the aerodynamic wake behind bodies of different configurations, including wing-shaped and cylindrical bodies. The experiments were carried out in a wind tunnel for Mach 2.5-4 and angles of attack up to 30 deg. Shock waves were generated by a simplified round air intake or a wedge. The effect of the vortex and shock wave intensities on flow structure in the interference region is determined. V.L.

A90-46554

WING DESIGN OPTIMIZATION UNDER STRESS-STRAIN CONSTRAINTS USING FULL-STRENGTH AND MINIMUM MASS CRITERIA [OPTIMIZATSIYA KONSTRUKTSII KRYLA PRI OGRANICHENIIAKH NA VELICHINU NAPRIAZHENII I DEFORMATSII S ISPOL'ZOVANIEM KRITERIEV RAVNOPROCHNOSTI I MINIMUMA MASSY]

E. I. KRIUCHKOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 60-66. In Russian. refs

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A method is proposed for optimizing the distribution of the load-bearing wing material using the minimum mass criterion in the presence of constraints with respect to stresses and strains. At the initial stage of the optimization procedure, a full-strength algorithm is used first and then a gradient method. The approach proposed here allows the use of simplified versions whereby gradients are calculated for the strain constraints only. The full-strength algorithm, the gradient projection method, and the combined method proposed here are compared using the optimization of a wing of small aspect ratio as an example. V.L.

A90-46559

A GENERALIZED RELATION FOR THE AERODYNAMIC EFFICIENCY OF PLANE BODIES [OBOBSHCHEENNAIA ZAVISIMOST' DLIA AERODINAMICHESKOGO KACHESTVA PLOSKIKH TEL]

V. IA. ZAVERTAILO TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 104-109. In Russian.

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Generalized expressions for the aerodynamic efficiency of plane bodies are obtained which are applicable to a wide class of flight vehicles. The values of the aerodynamic efficiency and relative aerodynamic efficiency of plane bodies calculated using the expressions proposed here are found to be in satisfactory agreement with experimental data. Derivations of the formulas are presented. V.L.

A90-46563

PROFILING OF THE SUPERSONIC COMPONENTS OF THREE-DIMENSIONAL CORRUGATED NOZZLES [O PROFILIROVANII SVERKHZVUKOVYKH CHASTEI GOFRIROVANNYKH PROSTRANSTVENNYKH SOPL]

M. P. LEVIN TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 123-126. In Russian. refs

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A solution is proposed for the problem of profiling the supersonic section of three-dimensional nozzles producing a uniform flow with a specified Mach number. Examples of calculations of such nozzles, representing flow surfaces in the three-dimensional section, are presented. It is shown that the length of such nozzles may be less than the length of similar nozzles representing flow surfaces in the axisymmetric section. V.L.

A90-46564

SOME POSSIBILITIES OF THE VORTEX LAYER METHOD FOR CALCULATING THE AERODYNAMIC CHARACTERISTICS OF AN AUGMENTED AIRFOIL INTERACTING WITH THE ENGINE JET [NEKOTORYE VOZMOZHNOСТИ METODA VIKHREVOGO SLOIA DLIA RASCHETA AERODINAMICHESKIKH KHA RAKTERISTIK MEKHANIZIROVANNOGO PROFILIA PRI NALICHII DOPOLNITEL'NOGO OBDUVA STRUEI DVIGATELIA]

N. B. VORONTSOVA TsAGI, Uchenye Zapiski (ISSN 0321-3439),

vol. 20, no. 6, 1989, p. 1-7. In Russian. refs
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The problem of interaction between an augmented profile and the engine jet is examined, with power supply modeled by discontinuous changes of the full and static pressures in the active section. Examples of calculations of various configurations are presented. Based on calculations of boundary layer characteristics, the optimal position of the slat and the change in the critical angle of attack of a slat-equipped augmented airfoil are determined for the case of airfoil-jet interaction. V.L.

A90-46565

AN EXPERIMENTAL STUDY OF THE COMBINED EFFECT OF LONGITUDINAL RIBLETS AND VORTEX BREAKERS ON TURBULENT FRICTION [EKSPERIMENTAL'NOE ISSLEDOVANIE SOVMESTNOGO VLIYANIYA PRODOL'NOGO OREBRENIIA I RAZRUSHITELEI VIKHREVYKH STRUKTUR NA TURBULENTNOE TRENIE]

I. V. GUDILIN, G. V. ENIUTIN, A. I. KIM, I. A. LASHKOV, and V. G. SHUMILKIN TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 8-14. In Russian. refs
Copyright

The combined effect of longitudinal riblets and vortex breakers on the turbulent friction resistance of a flat plate was investigated experimentally in a low-turbulence wind tunnel (flow turbulence, 0.02-0.04 percent). It is found that the combined effect of riblets and vortex breakers corresponds to the sum of their individual effects when used separately. The combined use of riblets and vortex breakers has made it possible to reduce the full turbulent friction coefficient on the plate by 12-13 percent. V.L.

A90-46566

DETERMINATION OF THE LAMINAR-TURBULENT TRANSITION POINT FOR A TURBULENT LAYER ON A YAWING WING [OPREDELENIE TOCHKI PEREKHODA LAMINARNOGO POGRANICHNOGO SLOIA V TURBULENTNYY NA SKOL'ZIASHCHEM KRYLE]

O. V. KARAS', V. E. KOVALEV, and V. A. KUPAREV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 15-20. In Russian. refs
Copyright

A method for calculating the stability of a laminar boundary layer on a yawing wing is described which includes external flow analysis, laminar boundary layer calculation, and boundary layer stability analysis. The stability analysis is carried out in the linear approximation, with particular reference to Tollmien-Schlichting and transverse friction instabilities. Results of calculations of boundary layer stability for a yawing wing of elliptical profile are presented. V.L.

A90-46567

ACOUSTIC EXCITATION OF BOUNDARY LAYER OSCILLATIONS ON A YAWING WING [VOZBUZHDENIE ZVUKOM KOLEBANII POGRANICHNOGO SLOIA NA SKOL'ZIASHCHEM KRYLE]

A. V. DOVGAL', V. V. KOZLOV, and O. A. SIMONOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 21-26. In Russian. refs
Copyright

The susceptibility of a three-dimensional boundary layer on a yawing wing model to acoustic oscillations of flow was investigated experimentally using a low-turbulence subsonic wind tunnel. In particular, attention is given to the generation of nonstationary perturbations leading to the laminar turbulent transition in the positive pressure gradient region is examined. The three-dimensional structure of these perturbations is examined. V.L.

A90-46568

FLOW PAST BODIES WITHIN A NARROW CLASS OF CROSS-SECTIONAL SHAPES WITH STATIONARY SEPARATION ZONES AT LARGE REYNOLDS NUMBERS [OBTEKANIE TEL UZKOGO KLASSA FORM SECHENIIA SO STATSIONARNYMI SRYVNYMI ZONAMI PRI BOL'SHIKH CHISLAKH REYNOL'DSA]

G. I. TAGANOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 27-47. In Russian. refs
Copyright

A solution is presented for the problem of constructing a limiting plane separation flow at large Reynolds numbers for a class of nonsymmetrical bodies with one or two tapered edges with a zero taper angle. It is shown, in particular, that the consideration of separated flow past a sharp trailing edge involving the formation of a stationary point separation zone makes it possible to obtain specific values of the dissipation integral and impulse loss thickness for the second dissipation trail while retaining infinite flow velocity for the leading edge. For a flat plate, aerodynamic characteristics are determined over the entire range of angles of attack for the case of separated flow past both edges. V.L.

A90-46573

CALCULATION OF THREE-DIMENSIONAL FLOW PAST A PLANE SUPERSONIC AIR INTAKE AT ANGLES OF ATTACK AND SIDESLIP [RASCHET PROSTRANSTVENNOGO OBTEKANIIA PLOSKOGO SVERKHZVUKOVOGO VOZDUKHOZABORNIKA PRI NALICHII UGLOV ATAKI I SKOL'ZENIIA]

S. M. BOSNIAKOV, S. V. MIKHAILOV, and N. S. IATSKHEVICH TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 89-95. In Russian. refs
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Three-dimensional flow past a plane supersonic air intake with thick side walls at angles of attack and sideslip is calculated using the algorithm proposed by Bosniakov et al. (1984, 1988, 1989). The algorithm allows for the displacing effect of the boundary layer; the bow shock is isolated explicitly. The results obtained are compared with experimental data and calculations by a different method. V.L.

A90-46575

GASDYNAMIC CHARACTERISTICS OF A PLANE OR AXISYMMETRIC NOZZLE WITH A RECTILINEAR GENERATRIX OF THE SUPERSONIC SECTION [GAZODINAMICHESKIE KHKARAKTERISTIKI PLOSKOGO ILI OSESIMMETRICHNOGO SOPLA S PRIAMOLINEINOI OBRAZUIUSHCHEI SVERKHZVUKOVOI CHASTI]

V. A. ALEKSEENKO, V. P. SAFONOV, and S. A. SHCHERBAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 100-104. In Russian. refs
Copyright

Calculations of flow of an ideal gas in conical and plane nozzles using a modified Godunov scheme are reported. The integral and local characteristics of the nozzle are calculated as a function of the angle of taper of the supersonic section of the nozzle. Results of the numerical calculations are compared with analytical and the available experimental data. V.L.

A90-46615

APPLICATION OF SPLINES TO THE CALCULATION OF FLOW PAST A WING PROFILE [PRIMENENIE SPLAINOV K RASCHETU OBTEKANIIA KRYLOVOGO PROFILIA]

E. V. RYBALKO Moskovskii Universitet, Vestnik, Seria 1 - Matematika, Mekhanika (ISSN 0579-9368), May-June 1990, p. 66-70. In Russian. refs

Copyright

A numerical method based on the systematic application of splines is developed for calculating the potential flow of an incompressible fluid past a wing profile. The approach used makes it possible to calculate slender profiles as well as profiles with slender tail parts. Results are presented on the ONERA-D profile. B.J.

A90-46621

EFFECT OF SHOCK WAVES AND JETS ON STRUCTURAL ELEMENTS: MATHEMATICAL MODELING IN NONSTATIONARY GAS DYNAMICS [VOZDEISTVIE UDARNYKH VOLN I STRUI NA ELEMENTY KONSTRUKTSII: MATEMATICHESKOE MODELIROVANIE V NESTATSIONARNOI GAZODINAMIKE]

VLADIMIR N. LIAKHOV, VIKTOR V. PODLUBNYI, and VIKTOR V. TITARENKO Moscow, Izdatel'stvo Mashinostroenie, 1989, 392 p. In Russian. refs

Copyright

The book is concerned with the interaction of shock waves and their effect on various profiles, spherical, cylindrical, and blunt bodies, obstacles of rectangular shape, and cavities. Analytical and numerical methods are presented for solving problems for such processes. In particular, attention is given to the fundamentals of the asymptotic theory of two-dimensional shock wave processes, self-similar problems of the effect of shock waves on structural elements, effect of shock waves on flight vehicles, and application of the local theory to the study of gas flows with shock waves.

V.L.

A90-46645#

INVESTIGATION OF PROPELLER SLIPSTREAM EFFECTS ON THE FOKKER 50 THROUGH IN-FLIGHT PRESSURE MEASUREMENTS

P. C. M. VAN DEN BORNE and J. VAN HENGST (Fokker Aircraft, Amsterdam, Netherlands) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 16 p. refs (AIAA PAPER 90-3084) Copyright

An effort was made to measure the pressure distributions in flight and to determine the effect of the propeller slipstream on the wing, nacelle, and tailplanes of the Fokker 50. The flight test comprised a combination of conditions with variations in angle of attack, flap angle and propeller thrust. When wing pressure distributions are compared with Euler code results they show good agreement at lower values of thrust coefficient and angle of attack but less satisfactory agreement at higher thrust coefficients and angles of attack. Total pressure increase on the horizontal tailplane due to the propeller slipstream compares fairly well with wind tunnel test results. Strain gage results are utilized to determine average downwash angles at the horizontal tailplane which are compared with wind tunnel measurements. Discrepancies up to 3 degrees in effective downwash angles have been observed.

R.E.P.

A90-46841*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

BOUNDARY-INTEGRAL METHOD FOR CALCULATING AERODYNAMIC SENSITIVITIES WITH ILLUSTRATION FOR LIFTING-SURFACE THEORY

E. CARSON YATES, JR. and ROBERT N. DESMARIS (NASA, Langley Research Center, Hampton, VA) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 1. Mansoura, Egypt, Mansoura University, 1990, p. 39-52. refs

The technique of implicit differentiation has been used in combination with linearized lifting-surface theory to derive analytical expressions for aerodynamic sensitivities (i.e., rates of change of lifting pressures with respect to general changes in aircraft geometry, including planform variations) for steady or oscillating planar or nonplanar lifting surfaces in subsonic, sonic, or supersonic flow. The geometric perturbation is defined in terms of a single variable, and the user need only provide simple expressions or similar means for defining the continuous or discontinuous global or local perturbation of interest. Example expressions are given for perturbations of the sweep, taper, and aspect ratio of a wing with trapezoidal semispan planform. The present process appears to be readily adaptable to more general surface-panel methods.

Author

A90-46843*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

UNSTEADY AERODYNAMICS - PHYSICAL ISSUES AND NUMERICAL PREDICTIONS

JOHN W. EDWARDS (NASA, Langley Research Center, Hampton, VA) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 1. Mansoura, Egypt, Mansoura University, 1990, p. 99-115. refs

The current status of computational methods for unsteady aerodynamics is reviewed. The need to match the fluid dynamic flow equation level to the complexity of the type of unsteady flow under consideration is discussed. Comparisons of computational predictions with experimental unsteady pressures and flutter boundaries are presented. The treatment of complex aircraft geometries is also described.

Author

A90-46848*# Analytical Services and Materials, Inc., Hampton, VA.

APPLICATION OF LOCALIZED SURFACE HEATING TO ACTIVELY CONTROL THE BOUNDARY LAYER SEPARATION

NABIT M. EL-HADY (Analytical Services and Materials, Inc., Hampton, VA) and LUCIO MAESTRELLO (NASA, Langley Research Center, Hampton, VA) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 1. Mansoura, Egypt, Mansoura University, 1990, p. 263-269. refs

The use of localized surface heating to improve the performance of the airfoil of a fixed wing or rotating blade at high angle of attack is considered. Separation control by active means can be accomplished by acoustic perturbation of the separated area above the airfoil or by localized surface heating in a pressure gradient region. Active control by sound in the vicinity of the leading edge of an airfoil is shown to greatly reduce the area of separation. Therefore, the overall circulation is sufficiently changed to result in an increase in lift and a reduction in drag.

R.E.P.

A90-46850*# Old Dominion Univ., Norfolk, VA.

INTERACTIVE GRID ADAPTION

JAMSHID S. ABOLHASSANI (Old Dominion University, Norfolk, VA) and ERIC L. EVERTON (NASA, Langley Research Center, Hampton, VA) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 1. Mansoura, Egypt, Mansoura University, 1990, p. 309-317. (Contract NCC1-68)

An interactive grid adaption method is developed, discussed and applied to the unsteady flow about an oscillating airfoil. The user is allowed to have direct interaction with the adaption of the grid as well as the solution procedure. Grid points are allowed to adapt simultaneously to several variables. In addition to the theory and results, the hardware and software requirements are discussed.

Author

A90-46857#

UNSTEADY AERODYNAMICS OF DELTA WINGS, UNDERGOING RAMP-MANEUVERING IN PITCH TO POST-STALL ANGLE OF ATTACK

MOHAMMAD-AMEEN M. JARRAH (Stanford University, CA) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 1. Mansoura, Egypt, Mansoura University, 1990, p. 383-400.

A90-46869#

NUMERICAL SIMULATION OF STEADY AND UNSTEADY VORTICAL FLOWS AROUND WINGS AND BODIES

OSAMA A. KANDIL (Old Dominion University, Norfolk, VA) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 557-572. refs

This paper deals with numerical simulation of steady and unsteady vortex-dominated flows, including shock waves, around rigid and deforming delta wings and slender pointed bodies over wide ranges of incidence, Mach number and Reynold number. A unified, general formulation is presented by using the unsteady,

compressible, thin-layer, Navier-Stokes equations which are written in the conservation form relative to a moving frame of reference. Two implicit, finite-volume schemes are used either in pseudotime stepping or time-accurate stepping to obtain the solutions. For deforming solid boundaries, the grid deformation is updated by using the linearized Navier-displacement equations. Numerical examples include unsteady flows around oscillating rigid and deforming delta wings and steady and unsteady asymmetric vortex flows around a pointed forebody. Author

A90-46872*# Cincinnati Univ., OH.

FLOW SEPARATION IN OBLIQUE SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS

A. HAMED (Cincinnati, University, OH) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 633-648. refs

(Contract NAS1-18458)

Available experimental data on flow separation in shock wave turbulent boundary layer interactions are reviewed at hypersonic and supersonic speeds in two dimensional and axisymmetric interactions. The conditions leading to flow separation and the subsequent changes in the flow are discussed. The effects of the Mach number, Reynolds number, surface cooling and the methods of detecting separation are discussed. Pertinent experimental data for the separated flow characteristics in turbulent boundary layer oblique shock wave interactions are also presented and discussed. Empirical correlations for separated flows are also reviewed.

Author

A90-46876#

GEOMETRICAL FACTORS INFLUENCING THE FLOW FIELD IN A PROPULSIVE NOZZLE

M. M. KEMRY (Al-Azhar University, Cairo, Egypt) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 695-711. refs

The effect of changing the conical angle of an axisymmetric supersonic nozzle and the behavior of the flow field are investigated. Kliegel methodology is used to predict an initial value line in the throat region and the method of characteristics is used for solving the steady inviscid, compressible flow equations. This investigation includes the regions in the flow field that are affected by the conical angles and those that are affected by the throat arc and the initial value line. It is shown that there is a limiting value of the divergence angle that leads to optimal thrust. The tangential point is a source of oblique shock waves that come early as the wall angle decreases. Thus, increasing the wall angle serves to increase the Mach number and decrease the static properties.

R.E.P.

A90-46879*# McDonnell-Douglas Helicopter Co., Mesa, AZ.

NUMERICAL SIMULATIONS OF THREE-DIMENSIONAL ROTOR BLADE-VORTEX INTERACTIONS

A. A. HASSAN and B. D. CHARLES (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 745-749. refs (Contract NAS1-17145)

A numerical procedure which has been developed (Hassan and Charles, 1989) for the prediction of helicopter blade loads during self-generated blade-vortex interactions (BVI) is described. These BVIs result in significant and frequent impulsive changes in the rotor blade aerodynamic loads and moments that are known to lead to vibrations and severe noise problems. Potential BVIs are identified and tracked in time at even increments of rotor azimuth employing the lifting line helicopter/rotor trim code CAMRAD. The accuracy of the predicted leading edge pressures for self-generated interactions is shown to rely heavily on the user-specified vortex core radius, and more significantly on the CAMRAD-predicted geometry of the interaction vortex elements and their relative orientation with respect to the blade. Thus, the

robustness of the surface transpiration approach for modeling subcritical-type BVIs is proven. R.E.P.

A90-46880#

ROTOR LOADS COMPUTATION USING SINGULARITY METHODS AND APPLICATION TO THE NOISE PREDICTION

MARTIN SCHAFFAR and JACQUES HAERTIG (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 751-763. refs

The 2D space, two singularity methods are described and applied to the profile/vortex interaction. The results show good agreement with experiments in a water tunnel. In 3D space, the Vortex Lattice Method with a local conformal mapping is described and applied in order to predict the aerodynamic loads on a thick two-bladed rotor. The pressure coefficients obtained for the thick rotor are fed into an acoustic code which is based on the Ffowcs-Williams-Hawkings equation. The results obtained with this method show the importance of the rotor and flight parameters; they are compared with results found in the literature for a two-bladed rotor in hovering and advancing flight. The comparison shows a good agreement and exhibits that the cut-off length used to smooth the singularity of the Biot and Savart law must be chosen carefully.

Author

A90-46881#

NUMERICAL SIMULATION OF WAKES WITH APPLICATION TO BLADE-VORTEX INTERACTION

BONIAN DONG and DEAN T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 765-775. refs

Blade-vortex interaction is investigated in this paper. First, the wake created by a pitching airfoil is simulated. Second, blade-vortex interaction is modeled by placing another airfoil in the wake of the pitching airfoil. The flow is assumed to be two-dimensional, inviscid and incompressible. Also, the present numerical model is based on the assumption that the flow is always attached. The comparison of numerical and experimental results are presented. It is shown that the vortices in the wake behave almost like inviscid ones. However, the present numerical simulation of an earlier experiment investigating blade-vortex interaction is not in good agreement with the experiment. A possible explanation for the poor agreement is that the flow separates.

Author

A90-46884#

TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLE FLOW WITH WALL VELOCITY SLIP AND TEMPERATURE JUMP

N. I. I. HEWEDY, M. A. EL-KADY, and M. A. HAMED (Menoufia University, Shebeen El-Koam, Egypt) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 821-833. refs

Predicted results are presented for the low-density flow through converging-diverging nozzle. The Navier-Stokes and energy equations are used with velocity slip and temperature jump at the wall. An implicit finite-difference scheme is used to calculate the flow parameters. Also, the calculated continuum flow results are compared with that of slip-flow. The cases chosen for presentation show the effect of varying the nozzle geometry and the Reynolds number. The results suggest that the velocity slip reduced the wall friction coefficient. Also, rapid increasing or dropping is apparent upon the pressure and Mach number profiles at the throat in the case of a sharp-throat nozzle.

Author

A90-46942#

EMPIRICAL PREDICTION OF THE BLOCKAGE EFFECT OF A FLAT BODY ON A ROTOR

A. NURICK (Witwatersrand, University, Johannesburg, Republic of South Africa) and J. C. F. MARTINS IN: Vertical Lift Aircraft

Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 22 p. refs

The blockage effect of various flat bodies on a rotor in hover, at a number of separation distances, was determined for both tractor and pusher configurations. The blockage effects were measured using a whirl tower fitted with a five bladed rotor, with untwisted rotor blades, having a diameter of 3m. Empirical relationships were derived to predict the blockage effects and the results obtained using these relationships are compared with those obtained using existing methods. The empirical relationships derived include adjustments to account for the change in flow geometry that occurs when the size of the bodies are altered relative to that of the rotor. Author

A90-46943#

IMPROVEMENT TO INTERACTIVE TWO DIMENSIONAL ROTOR SECTION DESIGN

MARILYN J. SMITH and AHMED A. HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 8 p. refs

An interactive design procedure has been developed and applied in the design of two-dimensional rotor airfoils. The procedure utilizes a number of Computational Fluid Dynamics (CFD) codes originally developed for the design and analysis of airfoils for fixed wings. In the present paper, this procedure has been modified as necessary for direct application to rotors. Rotor airfoil sections are first sought using an inverse inviscid full-potential code with an initial pressure distributions. The engineer interactively alters the initial pressure distribution, in an iterative process, to meet the desired aerodynamic and geometric design constraints. The design process continues with the viscous analysis of the newly designed section using a full-potential direct code coupled with an integral boundary layer calculation. The coupled inviscid-viscous calculations are used to provide the linear aerodynamic characteristics for the designed airfoil section. A two-dimensional full Reynolds-averaged Navier-Stokes code is then utilized to compute the airfoil characteristics at and near stall. Correlations with wind tunnel test data indicate that accurate predictions are obtained via this method for the aerodynamic loads and shock strength and location. This design methodology is accurate and efficient, therefore allowing for the timely design of rotor airfoils. Author

A90-46945*# Kansas Univ. Center for Research, Inc., Lawrence.

EXPERIMENTAL INVESTIGATION OF WINGTIP AERODYNAMIC LOADING

JOHANNES M. VAN AKEN (University of Kansas Center for Research, Inc., Lawrence) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 13 p. refs (Contract NCC2-112; NCC2-417)

An experimental investigation was performed to obtain the aerodynamic loading of a series of wingtips. The wingtips varied in taper ratio (1.0, 0.6, and 0.3) and in sweep angle (0, 20, 30, 35, and 45 deg). The wingtips were tested separately (wingtip only configuration) and while mounted on a semi-span wing. The quarter-chord sweep angle of the wing was varied from 30 deg forward sweep, to unswept, to 30 deg. aft sweep. Wingtip loading was obtained from a six component strain-gauge balance mounted in the wingtip. The effect of wing sweep and wingtip taper and wingtip sweep on the wingtip lift curve slope, drag polar, and pitching moment behavior is discussed. The obtained wingtip data was used to define blade tip platforms, suitable for use in the Free-Tip Rotor configuration. The Free-Tip Rotor has blade tips, which are allowed to weathervane into the blade tip's relative wind. A passive control moment is applied to the blade tip's pitch axis so as to cause blade tip motion around a prescribed null point providing a finite blade tip lift. Author

A90-46973#

TWO AND THREE DIMENSIONAL INDICIAL METHODS FOR ROTOR DYNAMIC AIRLOADS

T. S. BEDDOES (Westland Helicopters, Ltd., Yeovil, England) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 14 p. refs

Development of the indicial model is demonstrated in stages from idealized two- and three-dimensional cases through to the rotor application. By comparison with test and the results of Navier-Stokes and Euler calculations, it is shown that the indicial model is capable of simulating the forces and moments that result from the relevant modes of forcing which include blade/vortex interaction throughout the appropriate Mach number range. The resultant efficiency of the aerodynamic calculation is shown to permit aeroelastic and aeroacoustic studies which are not yet possible using more conventional approaches. For application to active control studies the formulation is particularly appropriate for both linear and nonlinear response. Author

A90-47220*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

UNSTEADY BLADE SURFACE PRESSURES ON A LARGE-SCALE ADVANCED PROPELLER - PREDICTION AND DATA

M. NALLASAMY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 18 p. refs

(AIAA PAPER 90-2402) Copyright

An unsteady three dimensional Euler analysis technique is employed to compute the flowfield of an advanced propeller operating at an angle of attack. The predicted blade pressure waveforms are compared with wind tunnel data at two Mach numbers, 0.5 and 0.2. The inflow angle is three degrees. For an inflow Mach number of 0.5, the predicted pressure response is in fair agreement with data: the predicted phases of the waveforms are in close agreement with data while the magnitudes are underpredicted. At the low Mach number of 0.2 (take-off) the numerical solution shows the formation of a leading edge vortex which is in qualitative agreement with measurements. However, the highly nonlinear pressure response measured on the blade suction surface is not captured in the present inviscid analysis. Author

A90-47299#

NUMERICAL CALCULATIONS OF FLOWS WITH SHOCK WAVES BY FLUX VECTOR SPLITTING METHOD

SHIGERU ASO and AKIO ONO Kyushu University, Technology Reports (ISSN 0023-2718), vol. 63, June 1990, p. 237-241. In Japanese, with abstract in English. refs

Two flux vector splitting methods of Steger-Warming and Van Leer are investigated to check their capabilities for the calculations of the flows near sonic point and discontinuity. The results show that Van Leer method is more powerful for those singularities. The transonic flow around a wing and the shock reflection processes by a ramp are simulated by the Van Leer method. For transonic flow a wing section of NACA 0012 is calculated under the conditions of freestream Mach number of 0.8 and attack angle of 1.25 degrees. The embedded shock wave on the upper surface is captured within only three mesh points. For shock reflection processes generated by a ramp, various shock-reflection patterns of regular reflection, single Mach reflection, complex Mach reflection, and double Mach reflection are simulated. Calculated results show excellent agreements with experimental results. Author

A90-47300#

NUMERICAL STUDY OF INTERACTION OF A JET WITH A SUPERSONIC CROSS FLOW

WEIGUANG HUANG, NOBUHIKO YAMASAKI, and MASANOBU

NAMBA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 63, June 1990, p. 243-285. In Japanese, with abstract in English.

The paper presents finite-difference method (FDM) solutions of the two-dimensional Navier-Stokes equations in a conservative-law form for a jet injected in a supersonic cross flow. The effects of the jet-main flow pressure ratio, the injection angle and the injection flow Mach number on the jet-main flow interaction are studied. It is found that the boundary layer separation and the shock pattern caused by jet-main flow interaction are heavily dependent upon not only the jet-main flow pressure ratio but also the injection flow Mach number. Author

A90-47301#

SPEED-UP OF THE STRONGLY IMPLICIT PROCEDURE WITH APPLICATION TO SUBSONIC/TRANSONIC POTENTIAL FLOWS

RACHEL GORDON (Technion - Israel Institute of Technology, Haifa) and RIMON ARIELI (Rafael Armament Development Authority, Haifa, Israel) AIAA Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1345, 1346. refs
Copyright

A modified version of the strongly implicit procedure (SIP) developed by Stone (1968) for solving partial differential equations is presented. The capabilities of the modified scheme are demonstrated and analyzed for the case of two-dimensional subsonic or transonic potential flow over airfoils. The improved technique accelerates the convergence rate of the SIP considerably. For the problem studied here, it was found to reduce the number of iterations required for convergence by 50-85 percent, when compared to the SIP. The modified technique is weakly sensitive to the choice of the parameter sequence alpha of the SIP, and its optimal relaxation parameters are almost independent of the grid size, grid type, or the type of equations to be solved. Author

A90-47303*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EXPERIMENTAL OBSERVATIONS OF TWO-DIMENSIONAL BLADE-VORTEX INTERACTION

EARL R. BOOTH, JR. (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1353-1359. Previously cited in issue 05, p. 611, Accession no. A88-18656. refs
Copyright

A90-47307*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

UNSTEADY EULER AIRFOIL SOLUTIONS USING UNSTRUCTURED DYNAMIC MESHES

JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1381-1388. Previously cited in issue 09, p. 1272, Accession no. A89-25102. refs
Copyright

A90-47312*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PREDICTION OF SEPARATED TRANSONIC WING FLOWS WITH NONEQUILIBRIUM ALGEBRAIC TURBULENCE MODEL

RIDHA ABID, VEER N. VATSA (NASA, Langley Research Center, Hampton, VA), DENNIS A. JOHNSON (NASA, Ames Research Center, Moffett Field, CA), and BRUCE W. WEDAN (Vigyan, Inc., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1426-1431. Previously cited in issue 09, p. 1283, Accession no. A89-25447. refs
Copyright

A90-47314#

CONTROL OF WALL-SEPARATED FLOW BY INTERNAL ACOUSTIC EXCITATION

FEI-BIN HSIAO, JONG-YAW SHYU (National Cheng Kung University, Tainan, Republic of China), and CHIN-FUNG LIU AIAA

Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1440-1446. Sponsorship: National Science Council of the Republic of China. Previously cited in issue 11, p. 1591, Accession no. A89-30488. refs

(Contract NSC-76-0401-E006-21)

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A90-47608

AIRFOIL DESIGN AND DATA

RICHARD EPPLER (Stuttgart, Universitaet, Federal Republic of Germany) Berlin and New York, Springer-Verlag, 1990, 568 p. refs

Copyright

The theoretical basis and numerical implementation of computer programs for the design and analysis of low-speed airfoils are discussed, and results on a wide variety of airfoil types are compiled in extensive tables and graphs. The focus is on improvements and extensions of the program developed by Eppler and Somers (1980). Chapters are devoted to potential flow, boundary-layer theory, and general considerations for the selection of design parameters. The airfoils characterized include designs for low Reynolds numbers, manpowered aircraft, sailplanes, high-lift applications, general-aviation aircraft, acrobatic aircraft, tailless aircraft, vertical and horizontal tails, propellers, helicopter rotor blades, hydrofoils, and nonlifting struts. The mathematical formulation of the inverse potential-flow method is outlined in an appendix. T.K.

A90-47700

WING THEORY

ROBERT T. JONES Princeton, NJ, Princeton University Press, 1990, 223 p. refs

Copyright

The fundamental principles of wing design are examined analytically in a work suitable for advanced students and practicing aeronautical engineers. Topics addressed include potential flow over ellipsoids, two-dimensional flow and wing-section theory, thin-airfoil theory, the influence of compressibility, the effects of sweep, wings of high aspect ratio, lifting-surface theory, the minimum drag of thin wings, and the drag of wing-body combinations. T.K.

A90-47854

IMPROVEMENT IN TURBINE BLADE AERODYNAMIC FORCE IN THE TIP REGION

TATSUO KAWAI, TSUTOMU ADACHI (Tsukuba, University, Japan), and SHUJI SHINOKI (Sumitomo Electric Industries, Ltd., Itami, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 33, Aug. 1990, p. 517-524. refs

Copyright

An attempt to increase the turbine blade aerodynamic force was made by installing boundary layer fences on the endwalls of a linear turbine rotor cascade. The height and location of the fences were varied to optimize these parameters. Static pressures measured on the passage surface correlated well with surface secondary flow patterns visualized by the oil flow method. The fences favorably attenuated local unloadings in the tip region of the suction surface associated with the endwall crossflow and the passage vortex three-dimensional separation, but unfavorably inhibited a passage-vortex-induced local loading also on the suction surface. The fences were most effective when their height was one-third of the inlet endwall boundary layer thickness and located half a blade pitch away from the blades. The optimum fences then reduced the tangential force defect to 60 percent of the unfenced blading value. Author

A90-48076

NATIONAL CONFERENCE ON AERODYNAMICS, 5TH, POONA, INDIA, MAY 24, 25, 1990, PROCEEDINGS

Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, 114 p. For individual items see A90-48077 to A90-48090.

Topics presented include optimal camber distributions with

multiple constraints, modeling free vortex flow on a planar swept wing, a vertical tail design for the base-line configuration of military combat aircraft, solutions of two-dimensional Euler equations with multigrid acceleration, and curvature effects on airfoil wake. Also presented are industrial aerodynamics, the incompressible potential flow about three-dimensional configurations, and a system study for command guided missiles. R.E.P.

A90-48077#

WINGER - COMPUTER CODE FOR AERODYNAMIC ANALYSIS OF WINGS

S. C. GUPTA (Institute of Armament Technology, Poona, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 101-104.

A computer code is developed for determining the pressure distribution on wings at subsonic and supersonic speeds within the framework of linearized potential flow conditions. Body fitting paneling is done and boundary conditions are satisfied on the surface. Pressure distributions are compared with experimental data. Author

A90-48078#

OPTIMAL CAMBER DISTRIBUTIONS WITH MULTIPLE CONSTRAINTS

S. C. GUPTA (Institute of Armament Technology, Poona, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 105-111.

This paper applies a multi-constrained optimization technique to the definition of aerofoil camber lines for minimum induced drag on a combat aircraft wing configuration. The problem is treated utilizing linear lifting surface type of analysis. Both subsonic and supersonic flow conditions are dealt. Comparison is made toward camber distributions and pressure difference coefficients. Present study is based on linearized theory and is restricted to planar wing system. The problem here is to find camber which will yield minimum drag due to lift for a given wing planform, flight Mach number, lift and specified moments. Author

A90-48079#

MODELLING FREE VORTEX FLOW ON PLANAR SWEPT WING

K. RAMESH (Defence Research Development Laboratory, Hyderabad, India) and S. C. GUPTA (Institute of Armament Technology, Poona, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 113-116. refs

Flow past highly swept wings is characterized by vortex dominated lift. Separated free vortex flow marks the nonlinear lift characteristics. This paper describes the problems faced in extrapolating the potential methodology toward the development of free vortex flows. Numerical algorithm and panel numeric holdups are discussed. Author

A90-48080#

VERTICAL TAIL DESIGN FOR BASE-LINE CONFIGURATION OF MILITARY COMBAT AIRCRAFT

K. IBRAHIM (Hindustan Aeronautics, Ltd., Bangalore, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 117-122. refs

Simple statistical correlations are evolved to choose size, relative location and geometry of vertical tail for baseline design configuration of military combat aircraft. These correlations reveal that the vertical tail size is proportional to fuselage volume. They further bring out that structural aspect ratio gradually increases with increase in thickness to chord ratio in the lower range, and tends to attain an asymptotic value in the higher range, clearly indicating that gains in structural aspect ratio are not commensurate with increase in thickness to chord ratio in the higher range. Taper ratio is found to be proportional to quarter chord sweep. Author

A90-48081#

AIRBRAKE DESIGN FOR BASE-LINE CONFIGURATION OF ADVANCED JET TRAINERS/LIGHT ATTACK AIRPLANES AND MILITARY COMBAT AIRPLANES

K. IBRAHIM (Hindustan Aeronautics, Ltd., Bangalore, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 123-127. refs

Figure of merit expression for airbrake size in terms of airplane weight, flight Mach number and airbrake deflection is derived. Airbrake design data of nineteen airplanes are analyzed and linear correlations between airbrake size and airplane weight are evolved to enable the airplane designer choose the airbrake size for base-line design configuration of advanced jet trainers/light attack airplanes and military combat airplanes. Besides, design guidelines regarding choice of other parameters are briefly outlined. Author

A90-48082#

INCOMPRESSIBLE POTENTIAL FLOW ABOUT THREE-DIMENSIONAL CONFIGURATIONS

N. SINGH (Indian Institute of Technology, Kharagpur, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 129-133. refs

A numerical method, based on the internal distribution of singularity has been developed to calculate incompressible potential flow about external store configurations attached to a wing-body combination, namely, a tip tank and a pylon-mounted external store. Source and vorticity singularities are distributed on the mean camber surface of the wing, while the fuselage and other non-lifting components carry a source distribution on its wetted surface. The singularity strengths are obtained by satisfying the flow tangency condition at selected points on all the wetted surfaces of the configurations. The results of the present method have been compared with other available theoretical results. Author

A90-48083#

COMPUTATIONAL AND EXPERIMENTAL STUDIES ON GROUND EFFECT OF A SLENDER WING TAILLESS DELTA AIRCRAFT

C. SURESH KUMAR, M. S. MODGIL, P. JAYASIMHA, and S. M. SEETHARAM (Hindustan Aeronautics, Ltd., Bangalore, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 135-139. refs

Ground effect results obtained using Vortex Lattice Method and Engineering methods are compared with wind tunnel data for a fighter aircraft configuration. This paper briefly describes the advantages and accuracy of VLM over datasheet methods. Author

A90-48085#

VISCOUS FLOW CHARACTERISTICS OVER A BLUNT CONE AT HYPERSONIC MACH NUMBERS BY USING A PNS CODE

SREEKANTH and N. M. REDDY (Indian Institute of Science, Bangalore, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 147-155. refs

Numerical simulation of viscous flow over a cone at relatively higher angle of attack at hypersonic Mach numbers is presented. The parabolized Navier-Stokes equations are used as the governing equations. A semiimplicit finite difference scheme coupled with the space marching is used in the present work. Detailed flow characteristics like velocity profiles, shock standoff distance, heating rates and aerodynamic forces variation along the length of the blunt cone at a 15-deg angle of attack at freestream Mach number = 10.6 are presented. Author

A90-48086#

SOLUTIONS OF TWO-DIMENSIONAL EULER EQUATIONS WITH MULTIGRID ACCELERATION

SAVITA MAHAJAN (National Informatic Centre, New Delhi, India)

and ANAND KUMAR (National Aeronautical Laboratory, Bangalore, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 157-164. refs

A multigrid scheme is applied to accelerate the convergence of solution of two-dimensional Euler equations to steady state. Results for flow over airfoils are presented. Author

A90-48089#

LIFT AND PITCHING MOMENT MEASUREMENTS ON A SWEEPED TAPERED WING IN OSCILLATORY VERTICAL GUSTS

K. P. SINHAMAHAPATRA and B. C. BASU (Indian Institute of Technology, Kharagpur, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 181-185.

This paper describes aerodynamic lift and pitching moment measurements on a low aspect ratio, swept and tapered flat plate wing in oscillatory vertical gust flows with varying frequency parameter. These experiments are conducted in a gust tunnel facility. The tunnel and other apparatus used during the experiments are briefly described in the paper. Experimental measurements are compared with a computational method developed in the department by Singh (1989). Author

A90-48090#

AIRCRAFT PASSING THROUGH A SINUSOIDAL GUST

S. BHATTACHARYA and N. SINGH (Indian Institute of Technology, Kharagpur, India) (National Conference on Aerodynamics, 5th, Poona, India, May 24, 25, 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, May 1990, p. 187-192. refs

An economical numerical method has been developed to calculate unsteady aerodynamic characteristics of an aircraft configuration passing through a vertical sinusoidal gust by taking advantage of the computational efficiency of internal distribution of singularities. The only approximation introduced in the method is the linearization of the problem with respect to the amplitude of oscillation. Various comparisons have been made to demonstrate the effects of different aircraft components on wing or tail pressure and lift distributions. Author

A90-48295

RESPONSE OF A SUBSONIC BOUNDARY LAYER TO A PULSED OSCILLATION OF A LOCALIZED REGION OF THE SURFACE IN THE FLOW [O VOSPRIMCHIVOSTI DOZVUKOVOGO POGRANICHNOGO SLOIA K IMPUL'SNOMU KOLEBANIJU LOKALIZOVANNOGO UCHASTKA OBTEKAEMOI POVERKHNOSTI]

S. V. MANUILOVICH Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 311, no. 2, 1990, p. 305-309. In Russian. refs Copyright

The paper presents a theoretical analysis of unsteady perturbations of a laminar boundary layer on a semiinfinite heat-insulated flat plate in the uniform flow of an ideal gas at zero angle of attack. Attention is given to the structure of three-dimensional perturbations generated by the pulsed oscillations of a small region of the plate. The present approach makes it possible to obtain a quantitatively reliable description of the perturbed flow in the range of Reynolds numbers characteristics for a laminar boundary layer. B.J.

A90-48711

THE TURBULENT NEAR WAKE OF A FLAT PLATE AT LOW REYNOLDS NUMBER

A. NAKAYAMA (Douglas Aircraft Co., Long Beach, CA) and B. LIU (California State University, Long Beach) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 217, Aug. 1990, p. 93-114. refs

(Contract NSF MEA-80-18565)

Copyright

Mean-velocity and turbulence measurements have been made in the turbulent near wake of a flat plate at various Reynolds numbers (Re) in order to investigate the low-Re effects in this

region. The results indicate that the low-Re effects are significant enough to partially explain the discrepancies in the existing mean-velocity data. While the Re-independent inner-law similarity of the boundary layers continues to exist, the width of the inner wake that develops within the inner-law region scales with the outer variable. Therefore, the mean velocity near the wake center line depends on Re. It is conjectured that this is due to the influence of the large eddies of the outer layer on the spreading of the inner wake. Measured turbulence quantities indicate that sudden changes occurring just downstream of the trailing edge are independent of Re, but the subsequent development of the turbulent stress profiles depends on Re. Author

A90-48712

HYPERVELOCITY FLOW OF DISSOCIATING NITROGEN DOWNSTREAM OF A BLUNT NOSE

M. N. MACROSSAN (Queensland, University, Brisbane, Australia) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 217, Aug. 1990, p. 167-202. Research supported by the Australian Research Council. refs

Copyright

The nonequilibrium flow of strongly dissociating nitrogen has been investigated by a series of simulation calculations using nonequilibrium (finite-rate) chemical reactions with the equilibrium flux method. The results are found to compare favorably with experimental results obtained with a free-piston-driven shock-tube wind tunnel, which was used to obtain interferograms of the flow of pure nitrogen over a 65-mm-long blunt-nosed body at three angles of incidence. No simple relation between the flow with nonequilibrium chemistry and those for frozen or equilibrium chemistry has been found. The problems of relating test flows produced in the shock tunnel to flight conditions are investigated, and it is shown that the degree of frozen dissociation in a shock tunnel is not a serious matter, but that the large difference in Mach number between shock tunnel flows and flight conditions may be more important. Author

A90-48715* Exeter Univ. (England).

WAVE INTERACTIONS IN A THREE-DIMENSIONAL ATTACHMENT-LINE BOUNDARY LAYER

PHILIP HALL (Exeter University, England) and SHARON O. SEDDOUGUI (NASA, Langley Research Center, Hampton, VA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 217, Aug. 1990, p. 367-390. refs

(Contract NAS1-18107)

Copyright

The three-dimensional boundary layer on a swept wing can support different types of hydrodynamic instability. Here attention is focused on the so-called 'spanwise instability' problem which occurs when the attachment-line boundary layer on the leading edge becomes unstable to Tollmien-Schlichting waves. In order to gain insight into the interactions that are important in that problem a simplified basic state is considered. This simplified flow corresponds to the swept attachment-line boundary layer on an infinite flat plate. The basic flow here is an exact solution of the Navier-Stokes equations and its stability to two-dimensional waves propagating along the attachment line can be considered exactly at finite Reynolds number. The corresponding problem is studied for oblique waves, and their interaction with two-dimensional waves is investigated. It is shown that there are two types of oblique wave which, if excited, cause the destabilization of the two-dimensional mode and the breakdown of the disturbed flow at a finite distance from the leading edge. Author

A90-48836* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A MACH 3 HIGH-SPEED CIVIL TRANSPORT CONFIGURATION

PETER F. COVELL, GLORIA HERNANDEZ, JEFFREY D. FLAMM (NASA, Langley Research Center, Hampton, VA), and OLLIE ROSE (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations

Conference, Dayton, OH, Sept. 17-19, 1990. 10 p. refs
(AIAA PAPER 90-3210) Copyright

The NASA-Langley AST31 high-speed civil transport (HSCT) configuration, a blended wing/fuselage concept scaled for 250-passenger carriage over 6500 nmi, has been subjected to both CFD and wind tunnel tests; the wind tunnel tests were conducted in the Mach 1.6-3.6 range. The inability of the linear theory method to accurately predict stability levels as well as nonlinear pitching moment characteristics demonstrates the need to undertake high-order analyses as early in the design process as possible. An HSCT laminar flow capability experimental study was conducted in order to simulate 50-percent laminar flow conditions, and thereby ascertain the difference in drag relative to fully turbulent conditions. O.C.

A90-48837*# Stanford Univ., CA.

A NUMERICAL METHOD FOR RELATING TWO- AND THREE-DIMENSIONAL PRESSURE DISTRIBUTIONS ON TRANSONIC WINGS

ILAN KROO (Stanford University, CA) and ALEXANDER J. M. VAN DER VELDEN AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 9 p. refs

(Contract NCA2-343)

(AIAA PAPER 90-3211) Copyright

This paper presents a preliminary design method for determining a wing's design pressure distribution and geometry based on airfoil normal Mach numbers and airfoil loading. In this method, the perturbation velocities in supercritical regions are computed from airfoil transonic normal Mach numbers and include the influence of local sweep, taper, and three-dimensional induced velocities, so that the appearance and strength of shocks can be expected to resemble those of the airfoil. The velocities in subcritical wing regions are scaled first with simple sweep theory, and then to achieve the desired load distribution. The method was applied to the design of an oblique flying wing, using a linear potential method. The required wing area could be reduced by 14 percent using this method rather than simple sweep theory. Author

A90-48838*# California Univ., Davis.

SUBSONIC AND TRANSONIC LOW-REYNOLDS-NUMBER AIRFOILS WITH REDUCED PITCHING MOMENTS

C. P. VAN DAM (California, University, Davis), R. HICKS (NASA, Ames Research Center, Moffett Field, CA), and J. REUTHER AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs

(AIAA PAPER 90-3212) Copyright

A subsonic and a transonic airfoil are presented for application in a high-altitude long-endurance aircraft and a very-high-altitude aircraft, respectively. The subsonic airfoil is designed for a lift coefficient $c(l) = 1.4$ at a chord Reynolds number $Re = 700,000$ and a very low Mach number. The transonic airfoil is designed for $c(l) = 1.0$ at $Re = 500,000$ and a transonic Mach number $M = 0.7$. Both airfoils are developed to perform as well or better than previously designed airfoils. However, the present airfoils are developed for a constrained pitching moment to reduce aircraft trim drag and to relieve, to some extent, the torsional loads in the typically high-aspect-ratio wings. The beneficial effects of a cruise flap and of boundary-layer transition control on the off-design performance characteristics are illustrated. Author

A90-48873#

AIRFOIL STATIC-PRESSURE THRUST - FLIGHT-TEST VERIFICATION

FABIO R. GOLDSCHMIED AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs

(AIAA PAPER 90-3286) Copyright

An experimental flight-test program of the 31.5 percent-thick GLAS II Modified laminar airfoil with single-slot boundary-layer control suction has verified static-pressure thrusts up to 90 percent of the skin-friction drag at lift coefficients corresponding to cruising speeds. It was also shown that the total GLAS II drag, including

the 'equivalent' boundary-layer control suction drag, was no greater than that of conventional 15 percent-thick laminar airfoils. Thus, static-pressure thrust must be accepted by aeronautical engineers as a quiet and power-efficient aircraft propulsion option for the 21st century. Author

A90-48953#

INTERACTIVE BOUNDARY-LAYER METHOD FOR UNSTEADY AIRFOIL FLOWS - QUASISTEADY MODEL

TUNCER CEBECI (Michigan, University, Ann Arbor) and HONG-MING JANG (Douglas Aircraft Co., Long Beach, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 673-678. Previously cited in issue 09, p. 1270, Accession no. A89-25016. refs

(Contract F49620-88-C-0020)

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A90-48954*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

EXPERIMENTAL INVESTIGATION OF MULTIELEMENT AIRFOIL ICE ACCRETION AND RESULTING PERFORMANCE DEGRADATION

M. G. POTAPCZUK (NASA, Lewis Research Center, Cleveland, OH) and B. M. BERKOWITZ (Sverdrup Technology, Inc., Brook Park, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 679-691. Previously cited in issue 10, p. 1432, Accession no. A89-28453. refs

Copyright

A90-49101*# Lockheed Engineering and Sciences Co., Houston, TX.

PARAMETRIC ANALYSIS OF SWEEP-WING GEOMETRY WITH SHEARED WING TIPS

C. M. FREMAUX (Lockheed Engineering and Sciences Co., Houston, TX), P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), and C. P. VAN DAM (California, University, Davis) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 16 p. refs

(Contract NCC1-47; NCA2-397; NAS1-18240)

(AIAA PAPER 90-3196)

A computational parameter study is presented of potential reductions in induced drag and increases in lateral-directional stability due to sheared wing tips attached to an untwisted wing of moderate sweep and aspect ratio. Sheared tips are swept and tapered wing-tip devices mounted in the plane of the wing. The induced-drag results are obtained using an inviscid, incompressible surface-panel method that models the nonlinear effects due to the deflected and rolled-up wake behind the lifting surface. The induced-drag results with planar sheared tips are compared to straight-tapered tip extensions and nonplanar winglet geometries. The lateral-directional static-stability characteristics of the wing with sheared tips are estimated using a quasi-vortex-lattice method. For certain combinations of sheared-tip sweep and taper, both the induced efficiency of the wing and the relevant static-stability derivatives are predicted to increase compared to the wing with a straight-tapered tip modification. Author

A90-49103*# Boeing Commercial Airplane Co., Seattle, WA. APPLICATION OF BOUNDARY LAYER CONTROL TO HSCT LOW SPEED CONFIGURATION

P. G. PARIKH, A. W. CHEN, N. J. YU, G. H. WYATT, and T. TIMAR (Boeing Commercial Airplanes, Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. refs

(Contract NAS1-18377)

(AIAA PAPER 90-3199) Copyright

The feasibility of using boundary layer control (BLC) on a high speed civil transport (HSCT) high lift configuration for low speed performance improvement is studied. The possibility of using a part of the suction system previously designed for cruise laminar flow control (LFC) for low speed BLC mode was explored. A suction scheme for BLC was devised for the HSCT high lift configuration. The extent of the suction regions and levels were

determined via panel method based inviscid flow analysis coupled with three-dimensional boundary layer analyses. The compatibility of the BLC suction requirements was assessed, and the modifications necessary to operate the system in both modes of operation, were determined. An assessment of the potential aerodynamic performance improvement resulting from an implementation of the BLC concept compared to an optimized simple flap configuration without BLC was made by an Euler code analysis of the simple flap configuration. Author

A90-49106#

CFD NEEDS IN CONCEPTUAL DESIGN

JAMES R. SNYDER (USAF, Washington, DC) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 8 p. refs (AIAA PAPER 90-3209)

The conceptual design process is outlined, including configuration, propulsion, sensitivity, and trade-off studies. Focus is placed on aircraft drag as the critical parameter for conceptual design and the computational fluid dynamic (CFD) approach involved. Semiempirical methods currently utilized for production aerodynamic works are assessed, and a simple example of the semiempirical modification of a theoretical aerodynamic equation is discussed. Numerical solutions provided by CFD methods to the full potential equation, the Euler equation, and various approximations of the Navier-Stokes equations are considered, and linear methods are analyzed. It is concluded that the linear/semiempirical approach to the estimation of aircraft aerodynamics may become the aerodynamic technique employed in conceptual design in the near future. V.T.

A90-49122#

A METHOD FOR LIFTING SURFACE DESIGN USING NONLINEAR OPTIMIZATION

ILAN KROO (Stanford University, CA) and SEAN WAKAYAMA AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. Research supported by the Boeing Co. refs (AIAA PAPER 90-3290) Copyright

This paper describes a method for the analysis and design of general non-planar lifting surface configurations. Aerodynamic and structural analyses are combined with numerical optimization to produce designs maximizing aerodynamic performance, subject to structural weight constraints. Lifting surfaces are represented by a discrete vortex Weissinger model with induced drag calculations based on a Trefftz plane analysis. Profile and compressibility drag are estimated from the lift distribution using section characteristics determined from experimental data. The wing structure is represented by a slender, single cell monocoque beam, with structural weight based on bending strength at multiple design conditions. Results illustrate that optimal designs are strongly affected by compressibility drag, aeroelasticity, and multiple structural design points. The method is also applied to the optimization of wing planform shape. Author

A90-49274

SELF-EXCITED OSCILLATIONS IN INTERNAL TRANSONIC FLOWS

G. E. A. MEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany), A. P. SZUMOWSKI, and W. C. SELEROWICZ (Warszawa, Politechnika, Warsaw, Poland) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 27, no. 2, 1990, p. 145-200. refs Copyright

The different forms of oscillations in internal transonic flows are systematically described. The mechanisms leading to the oscillatory self-excited flow character are clarified and substantiated by theoretical and experimental data. Strong acoustic disturbances are periodically transmitted upstream during these oscillations. Also, in a duct with a sudden enlargement of its cross-section, both the upstream and the downstream parts of the flow are often affected by severe oscillations. Especially in the supersonic and transonic

flow regime, oscillations are very strong and lead to noise of high intensity and high gas temperatures at the base of the cavity.

R.E.P.

A90-49452

TWO- AND THREE-DIMENSIONAL PROBLEMS OF UNSTEADY AERODYNAMICS OF LOW LOADED TURBOMACHINERY BLADE ROWS STAGES

K. K. BUTENKO, A. A. OSIPOV, and K. S. REENT (Tsentr'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 3-20. refs Copyright

Several problems are solved for unsteady ideal gas flow through turbomachinery blade rows and stages consisting of thin low loaded blades. The range of problems under consideration includes the problems of aerodynamic interaction of two plane cascades moving one relative to other, consisting of fixed or oscillating airfoils, the problem of aerodynamic interaction of two annular blade rows, rotating one relative to other, and the problem of unsteady flow through rotating annular row of blades at subsonic, supersonic and transonic (subsonic at the blade root and supersonic at the blade tip) velocities of the basic flow. By means of linear analysis of small disturbances these problems are reduced to the solution of integral equations on surface of one of the blades in every row. Developed calculation programs provide fast estimation of unsteady load on blades of rows and acoustic fields, generated by them. Author

A90-49455

A METHOD FOR PREDICTING STALL FLUTTER UNDER VARIABLE INTERBLADE PHASE ANGLE ALONG ROTATING DIRECTION

X. D. YANG, D. P. TAO, and S. ZHOU (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 43-52. refs Copyright

The prediction of stall flutter at turbomachinery always needs the assumption of constant interblade phase angle, in which all interblade phase angles of each blade at a rotor are the constant. In this paper, the basic principle of deforming actuator disk method is used to develop a new predicting method by solving linearized Euler's equation. The method can predict the stall flutter under variable interblade phase angle along the rotating direction. The comparison between the computation and the experiment shows that the most unstable blade predicted by the method is very close to the measured one. This proves the predicting method to be effective for practical usage in engineering. Author

A90-49458

VARIATIONAL FORMULATION OF 2-D UNSTEADY TRANSONIC AERODYNAMICS OF OSCILLATING CASCADES

GAO-LIAN LIU (Shanghai Institute of Mechanical Engineering, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 76-85. refs Copyright

A family of variational principles for two-dimensional unsteady transonic flow with shocks around oscillating cascades is presented, in which a theory is improved in two aspects. First, the nonreflecting inlet/outlet boundary conditions are incorporated. Secondly, a new unsteady Kutta condition is employed. This theory

serves as a sound theoretical basis for the finite element analysis of unsteady flow and is valid for perfect gas as well as for ideal steam. Author

A90-49459

FLOW FIELD AROUND AN OSCILLATING CASCADE

MAKOTO KOBAYAKAWA (Kyoto University, Japan) and MASAHIKO OGUSHI (All Nippon Airways, Ltd., Tokyo, Japan) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 86-92. refs Copyright

An implicit approximate factorization algorithm is applied to an unsteady cascade flow on dynamic grids. The compressible Navier-Stokes equation is used to solve high Reynolds number turbulent flow through a heaving cascade. The flow field of the cascade is very different from that of an airfoil. The shock is generated in the rear part of the cascade and is bent as the cascade goes upward. Author

A90-49460

NUMERICAL SIMULATION OF TRANSONIC FLOW THROUGH OSCILLATING AND MULTI-ROW TWO-DIMENSIONAL AIRFOIL CASCADES

A. B. ARKAD'EV, V. A. VANIN, and S. V. ERSHOV (AN USSR, Institut Problem Mashinostroeniia, Kharkov, Ukrainian SSR) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 93-107. refs Copyright

The problems of aerodynamic interaction of two and three reciprocally moving blade rows, as well as the unsteady flow about isolated oscillating airfoils in cascade are considered. The solution of the problems under review can be achieved through the set of algorithms which have been devised using the numerical integration of Euler equations by Godunov's difference scheme and its high resolution modifications. A computational analysis of turbine and compressor cascades has been made. An effect of flow regime, as well as mode, frequency, amplitude and phase shift of oscillating airfoils on the performance of cascades air damping has been investigated. The analysis of local parameters has enabled to get a deeper insight into the mechanisms of flutter origin. The influence of Strouhal number, ratio of blade-numbers and axial spacing on the unsteady forces has been examined for the aerodynamic interaction of two blade-rows. Effects of wake segments splitting have been achieved numerically as a result of the wake/rotor interaction. In the case of three blade-rows the influence of axial spacing and moving and static cascades blade-numbers ratios on unsteady loads has been in changing the relating tangential stator rows shift. Author

A90-49464

NUMERICAL SOLUTION OF 2-D TRANSONIC FLOW THROUGH AN AXIAL TURBINE STAGE

TADEUSZ CHMIELNIAK and WLODZIMIERZ WROBLEWSKI (Slask, Politechnika, Gliwice, Poland) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 135-146. refs Copyright

This paper presents the solution of the steady and unsteady two-dimensional transonic flow through an axial turbine stage. The rotational, adiabatic, inviscid flow of the perfect gas is considered. The analysis of the problem has been based on the time dependent Euler equations. In order to solve the problem, the finite volume method and a time-marching method have been applied. The

results of numerical calculations for a chosen geometry of an axial turbine stage are presented. Author

A90-49465

NUMERICAL SIMULATION OF THREE-DIMENSIONAL NONSTATIONARY FLOWS AND VARIABLE AERODYNAMIC FORCES IN TURBOMACHINE STAGES

V. I. GNESIN (AN USSR, Institut Problem Mashinostroeniia, Kharkov, Ukrainian SSR) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 147-166. refs Copyright

A nonstationary formulation is presented for a numerical method suitable for solving the transonic flow of an ideal gas passing through turbomachine blades in movement relative to one another. A full system of Euler equations is integrated on the basis of the principle of transition to a periodically nonstationary solution, as well as an explicit monotonous finite-difference scheme. The method achieves the derivation of time-variable fields of gasdynamic parameters, as well as of the nonstationary loads at the stator and rotor blades. Analytical results are presented for the passage flows and for nonstationary turbine stage aerodynamic performance at both design and off-design conditions. O.C.

A90-49475

MEASUREMENTS OF SIMULATED WAKE/ROTOR INTERACTION PHENOMENA IN TURBOMACHINERY

K. FUNAZAKI (Iwate University, Japan) and T. NISHIYAMA (Ishinomaki-Senshu University, Japan) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 287-300. refs Copyright

Experimental investigations on simulated wake/rotor interaction phenomena were conducted by use of moving bars ahead of the stationary airfoil cascade. Results of overall measurements on the unsteady flow field, including static pressure on the airfoil and outlet total pressure, give some insight into these complex phenomena. Comparisons between the measurements and the predictions have verified the prediction code to some extent; for unsteady total pressure, such a code brings out only qualitative agreement with the measurements. Time-variant total pressure loss distributions are shown to elucidate the mechanism of aerodynamic performance deterioration in turbomachines by upstream wakes. Author

A90-49776#

CONTROL OF LOW-SPEED AIRFOIL AERODYNAMICS

MOHAMED GAD-EL-HAK (Notre Dame, University, IN) (University of Notre Dame, Low Reynolds Number Aerodynamics Conference, Notre Dame, IN, June 5-7, 1989) AIAA Journal (ISSN 0001-1452), vol. 28, Sept. 1990, p. 1537-1552. Previously cited in issue 21, p. 3294, Accession no. A90-46376. refs Copyright

A90-49778#

ANALYSIS OF A PROPELLER IN COMPRESSIBLE, STEADY FLOW

VALANA L. WELLS (Arizona State University, Tempe) AIAA Journal (ISSN 0001-1452), vol. 28, Sept. 1990, p. 1555, 1556. Abridged. Copyright

This Synoptic describes an analytical method for solving the equation governing the inviscid, irrotational, compressible, potential flow about a propeller. The equation and boundary conditions are transferred to a noninertial system of coordinates rotating with the propeller, in which the basic problem becomes a steady one. The solution method takes advantage of the linearity of the model

by superposing a 'compressible' solution to the potential equation on an 'incompressible' wake solution. In addition, the boundary conditions are satisfied by dividing the flowfield at the propeller plane, solving the equations separately ahead of and behind this plane, and enforcing continuity matching conditions. Applying the final boundary condition yields an infinite-series integral equation for the unknown circulation distribution. A lifting-line method is used to produce numerical results. Presented results establish the effect of compressibility on the induced field. Author

A90-49800**THE RECEPTIVITY OF LAMINAR BOUNDARY LAYER FLOW TO LEADING EDGE VIBRATIONS**

W. K. CHIU and M. P. NORTON (Western Australia, University, Nedlands, Australia) *Journal of Sound and Vibration* (ISSN 0022-460X), vol. 141, Aug. 22, 1990, p. 143-164. Research supported by the Australian Research Grants Commission. refs Copyright

The receptivity of laminar boundary layer flow to leading edge vibrations has been studied experimentally. The experiments reported on in this paper include (1) a stable case and (2) an unstable case. These experiments identify the forcing field imposed by the vibrating leading edge and track the subsequent development of the unstable Tollmien-Schlichting waves. Detailed velocity measurements around the leading edge help in the identification of the source of such unstable boundary layer waves. The near-singular nature of the response of the fluid around the vibrating leading edge is found to be responsible for the generation of unstable boundary layer waves. Author

N90-26790 Georgia Inst. of Tech., Atlanta.**VELOCITY MEASUREMENTS ON A LIFTING ROTOR/AIRFRAME CONFIGURATION IN LOW SPEED FORWARD FLIGHT Ph.D. Thesis**

SHIUH-GUANG LIU 1988 217 p

Avail: Univ. Microfilms Order No. DA8916161

Aerodynamic interactions between rotorcraft components and the rotor wake are extremely complex. Existing theories or analytical models are inadequate to treat these problems properly and give satisfactory results. The main reasons for this are inadequate detailed physical insights into these complicated phenomena and the lack of a database for validation of new codes. Experiments in these areas are, therefore, important for providing the substantial information that is missing. The interactions between a rotor and an airframe are studied, emphasizing what happens as the vortex filaments from the rotor blade approach the airframe. Periodic and time-averaged velocities were measured using a laser velocimeter in planes parallel to and both above and below the rotor tip path plane. Velocity variations along horizontal lines above the airframe and measurements during vortex impingement were also obtained. Strong vortex interaction effects were observed in the wake flowfield, and the wake is also altered by the presence of the airframe. In order to provide more detailed understanding on the vortex-surface interaction phenomenon, a complete measurement program focused on the area on the surface where vortex impingement occurs was, therefore, performed.

Dissert. Abstr.

N90-26793# Aeronautical Research Labs., Melbourne (Australia).**ARLSUPER VERSION 1.0, PROGRAM USERS GUIDE**

I. H. GRUNDY Apr. 1990 33 p

(AD-A222693; ARL-STRUC-TM-526; DODA-AR-006-090) Avail: NTIS HC A03/MF A01 CSCL 20/4

The computer program ARLSUPER calculates linearized steady and oscillatory supersonic flow around a coplanar wing and tail, vertical fin configuration using an explicit finite difference scheme. In this version, surface and mode shapes may be entered in functional form or as a collection of data points. Generalized forces are calculated and are written out in a form compatible with available flutter solvers. GRA

N90-26796# Naval Research Lab., Washington, DC. Center of Fluid Dynamics Development Branch.

EXPERIMENTS WITH UNSTEADY, FREE SURFACE, THREE-DIMENSIONAL VORTICES IN A THERMALLY STABLE, STRATIFIED FLUID

M. B. STEWART, S. B. COHEN, and A. W. TROESCH (Michigan Univ., Ann Arbor.) 14 May 1990 31 p Sponsored by ONR, Arlington, VA

(AD-A222088; NRL-MR-6630) Avail: NTIS HC A03/MF A01 CSCL 01/1

The unsteady characteristics of a vortex pair formed behind a delta wing airfoil at a negative angle of attack have been studied experimentally in a large towing tank with a stable density stratification. Measurements of the vortex pair's upward migration and visualizations of the vortex circulation were made using the hydrogen bubble technique with a laser sheet illumination in the transverse plane. Axial visualizations of the vortex migration and axial velocities at the vortex core were made using the hydrogen bubble technique with a diffuse light source. The effects of the rising vortices and their circulation on the free surface temperature field was recorded using an imaging infrared radiometer mounted over the free surface. GRA

N90-26797# Naval Postgraduate School, Monterey, CA. Dept. of Aeronautics and Astronautics.

FLOW VISUALIZATION OF DYNAMIC STALL ON AN OSCILLATING AIRFOIL M.S. Thesis

BRUCE E. BRYDGES Sep. 1989 116 p

(AD-A222202) Avail: NTIS HC A06/MF A01 CSCL 01/1

Stroboscopic schlieren photography was used to investigate the effects of compressibility, reduced frequency, and amplitude on the dynamic stall of a NACA 0012 airfoil subjected to sinusoidal oscillation. The Mach number was varied from M at infinity = 0.25 to M at infinity = 0.45 (corresponding to a Reynolds number variation of Re = 450,000 to Re = 810,000); the reduced frequency was varied from k = 0.025 to k = 0.10. Oscillation amplitudes of alpha sub m = 5 deg and alpha sub m = 10 deg were compared. Schlieren photographs are presented, which document the dynamic stall vortex formation, convection, and shedding sequence for various experimental conditions. Additionally, a preliminary examination of the flow reattachment process was conducted. Data derived from the photographs indicates that increasing the compressibility causes dynamic stall to occur at lower angles of attack, while increasing the reduced frequency and/or the oscillation amplitude effectively delays dynamic stall effects to a higher angle of attack. Flow reattachment is sensitive to both Mach number and reduced frequency for low values of these parameters; when either the Mach number or reduced frequency is sufficiently high, the reattachment process stabilizes. GRA

N90-26798# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.

AERODYNAMIC/DYNAMIC INTERACTION Final Report, 1985 - 1989

DEAN T. MOOK and ALI H. NAYFEH 13 Apr. 1990 16 p

(Contract AF-AFOSR-0158-85; AF PROJ. 2307)

(AD-A222263; AFOSR-90-0554TR) Avail: NTIS HC A03/MF A01 CSCL 01/1

A numerical/analytical development of simulations of the interactions among aerodynamics, dynamics and control systems was performed. A new unsteady vorticity panel method, a new analytical model of wing rock, and new simulations of the responses of vehicle to control surface motions were developed. GRA

N90-26799# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.

OBTAINING CONSISTENT MODELS OF HELICOPTER FLIGHT-DATA MEASUREMENT ERRORS USING KINEMATIC-COMPATIBILITY AND STATE-RECONSTRUCTION METHODS

JAY W. FLETCHER May 1990 12 p Presented at the 46th Annual Forum of the American Helicopter Society, Washington,

DC, May 1990

(AD-A222533) Avail: NTIS HC A03/MF A01

A new method was developed for application of Kalman Filter/Smoothers to post-flight processing of helicopter flight test dynamic measurements. This processing includes checking for kinematic compatibility among the measurements, identification of a measurement error model, and reconstruction of both measured and unmeasured time histories. Emphasis is placed on identification of a parametric measurement error model which is valid for a set of flight test data. This is facilitated through a new method of concatenating several maneuver time histories. The method also includes a model structure determination step which ensures that a physically realistic parameterization has been achieved. Application of the method to a set of BO-105 flight test data is illustrated. The resulting minimally parameterized error model is shown to characterize the measurement errors of the entire data set with very little variation in the parameter values. Reconstructed time histories are shown to have increased bandwidths and signal to noise ratios. GRA

N90-26800*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ROTORCRAFT AEROMECHANICAL**STABILITY-METHODOLOGY ASSESSMENT. PHASE 2: WORKSHOP**

WILLIAM G. BOUSMAN Mar. 1990 270 p Prepared in cooperation with Army Aviation Systems Command, Moffett Field, CA

(NASA-TM-102272; NAS 1.15:102272; AD-A222543;

NASA-992-21-01-PHASE-2; USAVSCOM-TR-90-A-001-PHASE-2)

Avail: NTIS HC A12/MF A02 CSCL 01/1

Helicopter rotor aeroelastic and aeromechanical stability predictions for four data sets were made using industry and government stability analyses and compared with data at a workshop held at Ames Research Center, August 2-3, 1988. The present report contains the workshop comparisons. GRA

N90-27649*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE LANGLEY 14- BY 22-FOOT SUBSONIC TUNNEL: DESCRIPTION, FLOW CHARACTERISTICS, AND GUIDE FOR USERS

GARL L. GENTRY, JR., P. FRANK QUINTO, GREGORY M. GATLIN, and ZACHARY T. APPLIN Washington Sep. 1990 73 p

(NASA-TP-3008; L-16731; NAS 1.60:3008) Avail: NTIS HC A04/MF A01 CSCL 01/1

The Langley 14- by 22-foot Subsonic Tunnel is a closed circuit, single-return atmospheric wind tunnel with a test section that can be operated in a variety of configurations (closed, slotted, partially open, and open). The closed test section configuration is 14.5 ft high by 21.75 ft wide and 50 ft long with a maximum speed of about 338 ft/sec. The open test section configuration has a maximum speed of about 270 ft/sec, and is formed by raising the ceiling and walls, to form a floor-only configuration. The tunnel may be configured with a moving-belt ground plane and a floor boundary-layer removal system at the entrance to the test section for ground effect testing. In addition, the tunnel had a two-component laser velocimeter, a frequency modulated (FM) tape system for dynamic data acquisition, flow visualization equipment, and acoustic testing capabilities. Users of the 14- by 22-foot Subsonic Tunnel are provided with information required for planning of experimental investigations including test hardware and model support systems. Author

N90-27653*# Pioneer Aerospace Corp., Melbourne, FL. **ADVANCED RECOVERY SYSTEMS WIND TUNNEL TEST REPORT**

R. H. GEIGER and W. K. WAILES Aug. 1990 101 p (Contract NAS8-36631)

(NASA-CR-177563; A-90259; NAS 1.26:177563) Avail: NTIS HC A06/MF A01 CSCL 01/1

Pioneer Aerospace Corporation (PAC) conducted parafoil wind

tunnel testing in the NASA-Ames 80 by 120 test sections of the National Full-Scale Aerodynamic Complex, Moffett Field, CA. The investigation was conducted to determine the aerodynamic characteristics of two scale ram air wings in support of air drop testing and full scale development of Advanced Recovery Systems for the Next Generation Space Transportation System. Two models were tested during this investigation. Both the primary test article, a 1/9 geometric scale model with wing area of 1200 square feet and secondary test article, a 1/36 geometric scale model with wing area of 300 square feet, had an aspect ratio of 3. The test results show that both models were statically stable about a model reference point at angles of attack from 2 to 10 degrees. The maximum lift-drag ratio varied between 2.9 and 2.4 for increasing wing loading. Author

N90-27654*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A COMPARISON OF TWO CENTRAL DIFFERENCE SCHEMES FOR SOLVING THE NAVIER-STOKES EQUATIONS

C. M. MAKSYMUK, R. C. SWANSON (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.), and T. H. PULLIAM Jul. 1990 62 p

(NASA-TM-102815; A-90141; NAS 1.15:102815) Avail: NTIS HC A04/MF A01 CSCL 01/1

Five viscous transonic airfoil cases were computed by two significantly different computational fluid dynamics codes: An explicit finite-volume algorithm with multigrid, and an implicit finite-difference approximate-factorization method with Eigenvector diagonalization. Both methods are described in detail, and their performance on the test cases is compared. The codes utilized the same grids, turbulence model, and computer to provide the truest test of the algorithms. The two approaches produce very similar results, which, for attached flows, also agree well with experimental results; however, the explicit code is considerably faster. Author

N90-27655*# United Technologies Research Center, East Hartford, CT.

DEVELOPMENT OF A LINEARIZED UNSTEADY AERODYNAMIC ANALYSIS FOR CASCADE GUST RESPONSE PREDICTIONS Interim Report

JOSEPH M. VERDON and KENNETH C. HALL Washington Jul. 1990 65 p Original contains color illustrations

(Contract NAS3-25425)

(NASA-CR-4308; E-5533; NAS 1.26:4308; R90-957907-2) Avail: NTIS HC A04/MF A01; 12 functional color pages CSCL 01/1

A method for predicting the unsteady aerodynamic response of a cascade of airfoils to entropic, vortical, and acoustic gust excitations is being developed. Here, the unsteady flow is regarded as a small perturbation of a nonuniform isentropic and irrotational steady background flow. A splitting technique is used to decompose the linearized unsteady velocity into rotational and irrotational parts leading to equations for the complex amplitudes of the linearized unsteady entropy, rotational velocity, and velocity potential that are coupled only sequentially. The entropic and rotational velocity fluctuations are described by transport equations for which closed-form solutions in terms of the mean-flow drift and stream functions can be determined. The potential fluctuation is described by an inhomogeneous convected wave equation in which the source term depends on the rotational velocity field, and is determined using finite-difference procedures. The analytical and numerical techniques used to determine the linearized unsteady flow are outlined. Results are presented to indicate the status of the solution procedure and to demonstrate the impact of blade geometry and mean blade loading on the aerodynamic response of cascades to vortical gust excitations. The analysis described herein leads to very efficient predictions of cascade unsteady aerodynamic response phenomena making it useful for turbomachinery aeroelastic and aeroacoustic design applications. Author

AIR TRANSPORTATION AND SAFETY

N90-27657*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AERODYNAMICS OF A LINEAR OSCILLATING CASCADE
 DANIEL H. BUFFUM and SANFORD FLEETER (Purdue Univ., West Lafayette, IN.) Aug. 1990 265 p
 (NASA-TM-103250; E-5677; NAS 1.15:103250) Avail: NTIS HC A12/MF A02 CSCL 01/1

The steady and unsteady aerodynamics of a linear oscillating cascade are investigated using experimental and computational methods. Experiments are performed to quantify the torsion mode oscillating cascade aerodynamics of the NASA Lewis Transonic Oscillating Cascade for subsonic inlet flowfields using two methods: simultaneous oscillation of all the cascaded airfoils at various values of interblade phase angle, and the unsteady aerodynamic influence coefficient technique. Analysis of these data and correlation with classical linearized unsteady aerodynamic analysis predictions indicate that the wind tunnel walls enclosing the cascade have, in some cases, a detrimental effect on the cascade unsteady aerodynamics. An Euler code for oscillating cascade aerodynamics is modified to incorporate improved upstream and downstream boundary conditions and also the unsteady aerodynamic influence coefficient technique. The new boundary conditions are shown to improve the unsteady aerodynamic influence coefficient technique. The new boundary conditions are shown to improve the unsteady aerodynamic predictions of the code, and the computational unsteady aerodynamic influence coefficient technique is shown to be a viable alternative for calculation of oscillating cascade aerodynamics. Author

N90-27661# Poitiers Univ. (France). Lab. d'Etudes Aerodynamiques.

STUDY OF THE COMPRESSIBILITY EFFECTS ON THE TURBULENCE OF SUPERSONIC DRAGS Final Report [ETUDE DES EFFETS DE COMPRESSIBILITE SUR LA TURBULENCE DANS LES SILLAGES SUPERSONIQUES, RAPPORT FINAL]
 J. P. BONNET Dec. 1989 37 p In FRENCH
 (Contract DRET-87-034)
 (ETN-90-97448) Avail: NTIS HC A03/MF A01

The turbulent drag at supersonic flow conditions is characterized. Flow velocities at Mach numbers from 1.6 to 4.2 are considered. Hot-wire anemometers for supersonic wind tunnel tests are developed. The phenomena relating to the characteristics of the supersonic flow are investigated. The results allowed the validation of several calculation codes for compressible flow analysis. The results concerning the analysis of floating and mean fields is presented. ESA

N90-27663# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.

STUDY OF THE FLOW AROUND THE PROTOTYPE OF A300: RESULTS OF THE THIRD TEST CAMPAIGN AT F2 AND COMPARISON WITH CALCULATIONS [ETUDE DE L'ECOLEMENT AUTOUR DE LA MAQUETTE DE L'A300 ALLONGE: RESULTATS DE LA TROISIEME CAMPAGNE D'ESSAIS A F2 ET COMPARAISONS AUX RESULTATS DE CALCUL]
 C. GLEYZES Sep. 1989 82 p In FRENCH
 (Contract ONERA-3423-AN-131-D)
 (CERT-33/5025-29-DERAT; ETN-90-97481) Avail: NTIS HC A05/MF A01

The results of the third experiment campaign of a prototype of the A300 are reported. The experiments were performed in the F2 wind tunnel. The laminar boundary layers around the A300 are investigated. The results of the investigation on the aerodynamic drag showed the increase of turbulence induced by the fuselage. Based on the theoretical pressure field, boundary layer calculations were performed and compared with experimental results. The friction drag was evaluated and compared with the wind tunnel tests. ESA

Includes passenger and cargo air transport operations; and aircraft accidents.

A90-46004

AIRCRAFT GROUND DEICING CONFERENCE, DENVER, CO, SEPT. 20-22, 1988, PROCEEDINGS
 Warrendale, PA, Society of Automotive Engineers, Inc. (SAE P-217), 1989, 277 p. No individual items are abstracted in this volume.
 (SAE P-217) Copyright

The common practice and the new technologies of aircraft ground deicing in both North America and Europe are first described. The characteristics of deicing fluids are discussed; the introduction of the Type II fluids in North American operations is considered; and the use of central and remote deicing facilities is described. Ways to make the pilots' task (that is, confirming that the aircraft is clean prior to takeoff) easier are then addressed, and what the professional groups and committees are doing about the deicing problem is examined. B.J.

A90-46395#

THE WAKE VORTEX PROBLEM REVISITED
 RICHARD PAGE (FAA, Technical Center, Atlantic City, NJ) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 99-123.

The FAA Wake Vortex Program and its objectives are presented, with emphasis on new aircraft classification and separation standards, vortex advisory systems and procedures based on vortex behavior, new mechanisms for wake vortex alleviation, wake vortex models, measurement techniques, and user education materials and information. Focus is placed on an enhanced vortex advisory system, including its operational requirements, concept, prototype development and installation, operational evaluation, and specification. It is noted that in order to enhance the wake vortex system, an airborne Doppler sensor could be developed to locate and evade a wake vortex, and laser Doppler velocimeters could be improved to perform the automatic collection and analysis of wake vortex data. The utilization of the tower-fly-by technique and monostatic acoustic vortex sensing system is assessed. V.T.

A90-46930#

ROTORWASH FLOW FIELDS - FLIGHT TEST MEASUREMENT, PREDICTION METHODOLOGIES, AND OPERATIONAL ISSUES
 SAMUAL W. FERGUSON (EMA, Mansfield, TX) and J. DAVID KOCUREK (Computational Methodology Associates, Hurst, TX) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 10 p. refs

This paper examines rotor downwash (rotorwash) in the context of its effect on the operating environment of the generating rotorcraft. This environment can be defined as personnel, terrain and vegetation, vehicles, structures, as well as other rotorcraft or aircraft. Major topics discussed include the flight test measurement of rotorwash, analytical prediction methodologies, and associated operational and safety related issues. Research in-work and plans for future research are also briefly reviewed. Author

A90-47663#

CONTROL OF A TWIN LIFT HELICOPTER SYSTEM USING NONLINEAR STATE FEEDBACK
 J. V. R. PRASAD, MANOJ MITTAL, and DANIEL P. SCHRAGE (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 840-850. refs
 (AIAA PAPER 90-3408) Copyright

Feedback linearization technique is used to synthesize a

nonlinear controller based on state feedback for a twin-lift helicopter configuration utilizing a spreader bar. A seven degree of freedom nonlinear model of the twin-lift system is developed in the lateral/vertical plane. The feedback control computations are carried out using the complete nonlinear model without any order reduction. The nonlinear controller, in addition to providing stability augmentation, is capable of accepting pilot commands to move the load to a desired position. The performance of the controller in response to pilots' commands is illustrated using a nonlinear simulation of the model. The effects of parameter uncertainties in the aerodynamic and control models of the helicopters on the closed loop performance are assessed. Author

A90-48864#

A SELF-COMPENSATING AIRCRAFT RECOVERY SYSTEM (SCARS)

ROLF BRODERSEN and GREGORY SAUER (Martin Marietta Corp., Orlando, FL) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs

(AIAA PAPER 90-3273) Copyright

A self-compensating (model-reference adaptive) control system having multiple redundancy and majority voting logic that can be developed and installed on aircraft carriers is described. The feasibility of a closed-loop control system that removes the risk of aircraft losses due to a mistaken weight preset has been demonstrated by computer simulation. Installation of cable payout transducers (encoders), a signal processor, and a servo-actuator that can rectify the mis-set of a weight adjustment lever can resolve this problem. An expansion of the present design limits for off-center engagement and for speed and weight of the aircraft, as well as a reduction in stress levels and a corresponding increase in aircraft and arresting system service life can be realized by modifying the cable damper subsystems currently in use. R.E.P.

A90-48875#

AIR FORCE USE OF CIVIL AIRWORTHINESS CRITERIA FOR TESTING AND ACCEPTANCE OF MILITARY DERIVATIVE TRANSPORT AIRCRAFT

ROBERT I. MARX, DOUGLAS M. CHAPMAN, MARK J. LANGLEY, and RANDALL S. FOUTS (USAF, Transport Test Div., Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 38 p. refs

(AIAA PAPER 90-3289) Copyright

A review of commercial aircraft programs and the use of FAA certification criteria in the acquisition of off-the-shelf transport aircraft by the USAF to fulfill its airlift requirements is presented. In addition, major differences between military and commercial test programs and acquisition are cited to illustrate the principal benefits to the Air Force of this method. Significantly reduced acquisition time, and reduced ground and flight testing and development costs are shown as benefits of this process. The unique aspects of certification of military derivatives, recent initiatives to codify the processes, and the impacts on changes required in the manner in which the USAF currently contracts for aircraft are discussed. R.E.P.

A90-49107#

TWIN-ENGINE TRANSPORTS - A LOOK AT THE FUTURE

RICHARD W. TAYLOR (Boeing Commercial Airplanes, Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 15 p. (AIAA PAPER 90-3215) Copyright

Current Extended Twin-Engine Operations ('ETOPS') design and operational criteria have changed in recent years, on the basis of substantial evidence that twin-turboprop commercial aircraft, with requisite modifications, can reach rates of reliability and safety at least equaling three- and four-engined aircraft on long-range routes. The next step in ETOPS evolution will be the design, manufacture, and certification of aircraft whose reliability will suffice for extended-range routes from the very inception of their service

lives. Laboratory testing and flight testing exceeding the most severe operational conditions can confirm the inherent reliability of engines and airframes in extended-range service. O.C.

A90-49827#

HIGHLIGHTS OF RAE LIGHTNING STRIKE INVESTIGATIONS

G. A. M. ODAM (Royal Aerospace Establishment, Farnborough, England) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 1-10.

A brief survey of UK Military aircraft lightning strike experience is presented for the 11 year period June 1972 to September 1983. Some damage effects are discussed and incidents of particular interest noted, including several civilian incidents investigated by the author. Some comment is given concerning crashes caused or initiated by lightning and the need for a Lightning Protection Plan to be made at an early stage in the development of an aircraft is noted. Author

A90-49831#

COMPARISON OF FOUR LIGHTNING SIMULATION TESTS ON A COMPOSITE TEST BED AIRCRAFT

DEBORAH L. SHORTESS, WILLIAM W. COOLEY, and BARBARA G. MELANDER (Science and Engineering Associates, Inc., Seattle, WA) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 80-93. Research supported by FAA.

Experimental results of a lightning simulation technique evaluation are presented. The tests have provided transient response data for a test bed fabricated of advanced composite materials which represents a general aviation single-engine aircraft. The techniques evaluated were low-level continuous wave, low-level pulse, moderate-level pulse, and shock-excitation. The low-level pulse test provided rise rates near that of the severe lightning threat. The moderate-level pulse test provided current levels within an order of magnitude of the severe lightning threat. The shock-excitation test provided induced electric fields on the test bed to simulate the approach of a lightning channel. The moderate-level pulse test minimized analysis and was the more accurate of the techniques for extrapolating results. C.D.

A90-49832#

COMPARISON OF THE SWEEPED FREQUENCY CONTINUOUS WAVE, CURRENT PULSE, AND SHOCK-EXCITATION LIGHTNING SIMULATION TECHNIQUES

RUDY M. BRAZA, RANDY J. JOST (USAF, Institute of Technology, Wright-Patterson AFB, OH), and JAMES L. HEBERT (USAF, Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 94-104. refs

Various lightning simulation test techniques were conducted on the Lightning Test Object. The experimental tests on the cylinder were the swept frequency continuous wave, current pulse, and shock excitation methods. The research involved determination of the electric field and magnetic field response transfer functions for each simulation test technique. With these transfer functions, analysis and comparison of the external and internal field responses between the different methods were made. The validity of the linear model for the current pulse simulation technique was examined. Author

A90-49833#

AN ASSESSMENT OF ANALYTICAL METHODS AND LIGHTNING SIMULATION TEST TECHNIQUES USED IN LIGHTNING QUALIFICATION AND SURVEILLANCE TESTING

RANDY J. JOST (USAF, Institute of Technology, Wright-Patterson AFB, OH), MARY P. HEBERT, and JAMES L. HEBERT (USAF, Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1988

International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 105-112. refs

One of the many problems facing both the aircraft manufacturers and the end users of those aircraft is a way to insure that lightning protection of the aircraft has been properly implemented during construction. A closely related problem is a way to verify that the aircraft is still protected while in service or after required maintenance. A review of the current state of aircraft protection validation is presented. The results of current research in lightning simulation and testing are outlined. The various methods used for lightning simulation and analysis are compared for their suitability as a means for lightning protection qualification and surveillance. The importance of correctly characterizing the aircraft is emphasized. Author

A90-49834*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FINAL RESULTS OF THE NASA STORM HAZARDS PROGRAM
BRUCE D. FISHER, PHILIP W. BROWN (NASA, Langley Research Center, Hampton, VA), J. ANDERSON PLUMER (Lightning Technologies, Inc., Pittsfield, MA), and ALFRED J. WUNSCH, JR. (NASA, Langley Research Center; USAF, Systems Command, Hampton, VA) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 113-130. refs
(Contract NAS1-17703)

Lightning swept-flash attachment patterns and the associated flight conditions were recorded from 1980-1986 during 1496 thunderstorm penetrations and 714 direct strikes with a NASA F-106B research airplane. These data were studied with an emphasis on lightning avoidance by aircraft and on aircraft protection design. The individual lightning attachment spots, along with crew comments and on-board photographic data were used to identify lightning swept-flash attachment patterns and the orientations of the lightning channels with respect to the airplane. The full-scale in-flight data were compared to results from scale-model arc-attachment tests. The airborne and scale-model data showed that any exterior surface of this airplane may be susceptible to direct lightning attachment. In addition, the altitudes, ambient temperatures, and the relative turbulence and precipitation levels at which the strikes occurred in thunderstorms are summarized and discussed. It was found that the peak strike rate occurred at pressure altitudes between 38,000 ft and 40,000 ft, corresponding to ambient temperatures colder than -40 C.

Author

A90-49835#
CHARACTERIZATION OF CONFIGURATION EFFECTS ON LIGHTNING SIMULATION/QUALIFICATION TESTING

RANDY J. JOST (USAF, Institute of Technology, Wright-Patterson AFB, OH) and JAMES L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 133-143. refs

This paper discusses some of the issues involved in constructing valid ground-based and airborne simulations of the airborne lightning-aircraft interaction event for indirect effects testing. The experimental test setups described include a lightning test cylinder, swept-frequency continuous-wave test, current pulse test, and shock-excitation test. The cylinder response is found to be especially dependent on the particular simulation technique used and on the configuration used. The frequency domain technique is more accurate. C.D.

A90-49839#
VISUALIZATION OF CORONA DISCHARGES

PATRICK MARTINEZ (Toulouse, Centre d'Essais Aeronautique,

France) and CHRISTIAN BUIL (CNES, Toulouse, France) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 167-173. refs

The aim of this study is to define an efficient means of visualizing luminous corona phenomena. A spectral analysis shows that the sensor must, above all, be sensitive to short wavelengths. Photometry experiments show that in most cases we can deduct the value of the evacuated current from luminous intensity measurements. A sensitometry study underlines, on one hand, reciprocity failure of films for long exposures, and on the other hand, the efficiency of gaseous hypersensitization as well as that of cooling. Tests carried out with a CCD camera lead us to think that this sensor and the image data processing used with it are quite suitable for dealing with the problem of visualizing corona effects on an aircraft structure. Author

A90-49843#
GRUMMAN/FAA LIGHTNING STUDY - A POTENTIAL COUNTERMEASURE FOR LIGHTNING INDUCED FLASHBLINDNESS OF AIRCREW MEMBERS

H. D. KIVLIGHN, JR. (Grumman Corporate Research Center, Bethpage, NY) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 196-199. refs

The results of the first attempt to encounter lightning strikes on board the FAA Lightning Characteristics Aircraft are described. It was found that, although darkening rates decreased by factors of two to three when photochromic samples were excited through the aircraft cabin window, the optical densities obtained were nearly equivalent. The rate decreases were therefore ascribed to the composition of the soda-lime glass and not to the presence of specific UV absorbers. Laboratory simulation of a lightning flash yielded a rise time of 500 microsec and a pulse width of 2.4 ms. All of the plastic and glass samples revealed darkening responses within this time frame. The theoretical background for anticipating the effectiveness of a photochromic countermeasure is briefly addressed, as are the design and construction of the system used in the study. C.D.

A90-49844#
IN-FLIGHT AIRCRAFT LIGHTNING SURFACE CURRENT MODEL

MARK M. SIMPSON (Douglas Aircraft Co., Long Beach, CA) and MICHAEL J. KATZER (Boeing Military Airplane Co., Seattle, WA) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 200-204. refs
(Contract F33615-82-C-3406)

A model was developed to calculate the surface currents on aircraft struck by lightning. This model was made of a transmission line network and a lumped-parameter network model of the lightning channel. Pole frequencies and damping calculated from these models differed by 18 percent from ones calculated from measurements for the first three aircraft poles. This difference increased to 240 percent by the seventh pole. These pole frequencies and damping differed by 18 percent for lightning channel impedances varying from 400 ohms to 3,000 ohms.

Author

A90-49845#
VALIDATION OF GEMACS FOR PREDICTION OF LIGHTNING INDUCED ELECTROMAGNETIC FIELDS

DAVID S. MABEE, RANDY J. JOST (USAF, Institute of Technology, Wright-Patterson AFB, OH), JAMES L. HEBERT, and MARY P. HEBERT (USAF, Aeronautical Laboratories, AFB, OH) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum

03 AIR TRANSPORTATION AND SAFETY

to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 205-213. refs

The General Electromagnetic Model for the Analysis of Complex Systems (GEMACS) is used to model and perform a frequency domain analysis on the Air Force Lightning Test Object (LTO). The GEMACS results are compared to experimental data to evaluate GEMACS's ability to predict electromagnetic (EM) fields around the LTO. The intent of the present analysis is to provide a base line on how accurately GEMACS predicts lightning induced EM fields. Predicted results are compared to extensive measurements made on the LTO. Author

N90-27636# Japan Air Lines Co. Ltd., Tokyo.

DAILY FLIGHT OPERATION MONITORING IN JAL

S. DOI In DLR, Aircraft Integrated Monitoring Systems p 391-409 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Daily Flight Operation Monitoring (DFMO), which is the crew performance monitoring in Japanese Airlines (JAL), is outlined. It was introduced to improve flight safety as one of the major objectives of the aircraft integrated monitoring systems. Through the monitoring, many unexpected phenomena were observed and necessary actions were required. Examples and future plans for B747-400 are included. ESA

N90-27639# Bristow Helicopters Ltd., Redhill (England).

AIMS FOR HELICOPTERS

D. JESSE and D. W. BARR (Plessey Avionics Havant Ltd., England) In DLR, Aircraft Integrated Monitoring Systems p 457-480 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

In helicopters most of the flight safety critical components cannot be duplicated. In order to improve flight safety and to reduce operating costs, an AIMS systems is needed. The current progress on health and usage monitoring systems, and the need to satisfy the new civil aviation authority legislation on flight data recorders for helicopters are considered. A program which integrates both functions and provides proven hardware in time for the legislation, and is of practical use to the operators is described. ESA

N90-27641# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugmechanik.

MONITORING AND CONTROLLING FLIGHT IN WINDSHEAR

R. KOENIG In its Aircraft Integrated Monitoring Systems p 501-527 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Wind shear remains a problem to the flight safety of air traffic. From a suitable hazard definition, consisting of the energy loss of the aircraft in relationship to an acceptable value, analyses of uncontrolled, controlled, and manual landing approaches are shown. The windshear problem arises from the manual flight. Indicating the energy and power loss via signals sent into modified instruments improves the flight performance during manual flight. ESA

N90-27644# Bureau of Air Safety Investigation, Canberra (Australia). Flight Recorder Services Branch.

AUSTRALIAN EXPERIENCE IN FLIGHT RECORDER READOUT AND ANALYSIS

PAUL MAYES In DLR, Aircraft Integrated Monitoring Systems p 567-591 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Australia introduced requirements in the 1960's for the carriage of Flight Data Recorder (FDR) equipment. Those requirements

expanded as aircraft and equipment technology developed. The Bureau of Air Safety Investigation developed a sophisticated software approach to the analysis of the FDR data using state of the art Silicon Graphics IRIS 4D GT workstation. The resultant color solid model animation gives a representation of the aircraft flight path, aircraft instruments. Comparison with standard instrument approach procedures is possible. ESA

N90-27666# National Transportation Safety Board, Washington, DC. Bureau of Safety Programs.

ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA: US GENERAL AVIATION, CALENDER YEAR 1987

12 Dec. 1989 88 p

(PB90-138066; NTSB-ARG-89/01) Avail: NTIS HC A05/MF A01 CSCL 01/3

A statistical compilation and review is presented of general aviation accidents which occurred in 1987 in the United States, its territories and possessions, and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. There are five sections: All Accidents; Fatal Accidents; Serious Injury Accidents; Property Damage Accidents and Midair Collision Accidents. Several tables present accident parameters for 1987 accidents only, and each section includes tabulations which present comparative statistics for 1987 and for the five-year period 1982 to 1986. Author

N90-27667# Transportation Research Board, Washington, DC.

PUBLIC-SECTOR AVIATION ISSUES, 1987 TO 1988

GRADUATE RESEARCH AWARD PAPERS

1989 49 p

(PB90-191206; TRB/TRR-1218; ISBN-0-309-04813-3; LC-90-5426) Avail: NTIS HC A03/MF A01 CSCL 01/2

The 4 papers included here deal with the following areas: managing demand to reduce airport congestion and delays; practical methods for shifting general aviation traffic from commercial service airports to reliever airports; an examination of consensus-building techniques applied to the aircraft noise and airport access dilemma; and use of a knowledge-based expert system to maximize airport capacity in harmony with noise-mitigation plans. GRA

N90-27668# Lightning Technologies, Inc., Pittsfield, MA.

AIRCRAFT LIGHTNING PROTECTION HANDBOOK

F. A. FISHER, J. A. PLUMER, and R. A. PERALA (Electro Magnetic Applications, Inc., Denver, CO.) Sep. 1989 507 p

(Contract DTFA03-86-C-00049)

(AD-A222716; DOT/FAA/CT-89/22) Avail: NTIS HC A22/MF A03 CSCL 01/3

This handbook will assist aircraft design, manufacturing, and certification organizations in protecting aircraft against the direct and indirect effects of lightning strikes, in compliance with Federal Aviation Regulations. It presents a comprehensive text to provide the essential information for the in-flight lightning protection of all types of fixed/rotary wing and powered lift aircraft of conventional, composite, and mixed construction and their electrical and fuel systems. The handbook contains chapters on the natural phenomenon of lightning, the interaction between the aircraft and the electrically charged atmosphere, the mechanism of the lightning strike, and the interaction with the airframe, wiring, and fuel system. Further chapters cover details of designing for optimum protection; the physics behind the voltages, currents, and electromagnetic fields developed by the strike; and shielding techniques and damage analysis. The handbook ends with discussion of test and analytical techniques for determining the adequacy of a given protection scheme. GRA

N90-27669*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.

REAL-TIME ADAPTIVE AIRCRAFT SCHEDULING

STEPHAN E. KOLITZ and MOSTAFA TERRAB Jun. 1990 69 p

(Contract NAS2-12419)

(NASA-CR-177558; A-90198; NAS 1.26:177558) Avail: NTIS HC A04/MF A01 CSCL 01/3

One of the most important functions of any air traffic management system is the assignment of ground-holding times to flights, i.e., the determination of whether and by how much the take-off of a particular aircraft headed for a congested part of the air traffic control (ATC) system should be postponed in order to reduce the likelihood and extent of airborne delays. An analysis is presented for the fundamental case in which flights from many destinations must be scheduled for arrival at a single congested airport; the formulation is also useful in scheduling the landing of airborne flights within the extended terminal area. A set of approaches is described for addressing a deterministic and a probabilistic version of this problem. For the deterministic case, where airport capacities are known and fixed, several models were developed with associated low-order polynomial-time algorithms. For general delay cost functions, these algorithms find an optimal solution. Under a particular natural assumption regarding the delay cost function, an extremely fast ($O(n \ln n)$) algorithm was developed. For the probabilistic case, using an estimated probability distribution of airport capacities, a model was developed with an associated low-order polynomial-time heuristic algorithm with useful properties. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A90-46390

RADIO TECHNICAL COMMISSION FOR AERONAUTICS, ANNUAL ASSEMBLY AND TECHNICAL SYMPOSIUM, WASHINGTON, DC, DEC. 4-6, 1989, PROCEEDINGS

JOANN C. JAGO, ED. (Radio Technical Commission for Aeronautics, Washington, DC) Washington, DC, Radio Technical Commission for Aeronautics, 1989, 256 p. For individual items see A90-46391 to A90-46398.

The record addresses global satellite navigation systems and applications, systems improving terminal area operations and airport capacity, technology issues for new global systems, systems improving worldwide en route operations, and user community reaction to new systems. Potential benefits along with challenges offered to civil aviation by the cooperative use of the U.S. GPS and Soviet Union GLONASS are characterized. Attention is given to the automatic aircraft in a manual ATC system, independent operations on closely-spaced runways, and wake vortex problem. Worldwide, multisensor navigation using GPS, GLONASS, and LORAN-C is considered, along with time synchronization/distribution applications in navigation. Speakers also elaborated on the effective use of satellite systems for oceanic air traffic control, advanced architecture for domestic and global aviation systems, and future business aircraft cockpit. V.T.

A90-46391#

DEVELOPMENT OF COMMON GPS AND GLONASS AVIONICS STANDARDS

EDWARD T. BAYLISS, RAYMOND R. LAFREY, and PRATAP N. MISRA (MIT, Lexington, MA) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 27-39. Research sponsored by FAA. refs

A program undertaken to develop a technical basis for GNP-GLONASS user equipment standards is described. GPS and GLONASS system characteristics are outlined, and the civil use of the systems is considered, with emphasis on an integrity requirement: the system must be sufficiently robust so that the loss of any single satellite does not cause an undetected loss of

navigation accuracy. The program is reviewed, with focus placed on GLONASS characterization in terms of signal-in-space, an analytic facility to be used to evaluate alternative navigation and integrity solutions using both GPS and GLONASS signals, and on data collection and avionics standards. V.T.

A90-46392#

AN INTERNATIONAL CIVIL INTEGRITY COMPLEMENT TO GPS AND GLONASS

CALIN ROSETTI (ESA, Paris, France), JAI SINGH, GEORGE KINAL (INMARSAT, London, England), and PIERRE DIEDERICH (Racal Research, Ltd., England) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 41-55.

A proposal for an international value-added geostationary complement (the civil overlay) to the GPS and GLONASS systems is presented. The proposed solution to integrity is a geostationary repeater overlay incorporated into Inmarsat-3 satellite payloads. The payloads will retransmit GPS and GLONASS lookalike signals; carried with these two signals will be GPS and GLONASS integrity data along with correction information compensating for differences between GPS and GLONASS system reference times. Focus is placed on the potential signal and data format to be used for the GPS and GLONASS integrity warning aspect of the overlay, including GPS frame structure and GLONASS data structure. A satellite navigation package envisioned for Inmarsat-3 is shown, as well as looparound ranging for satellite positioning. An Inmarsat Pn test bed and test results are also described. V.T.

A90-46393#

INDEPENDENT OPERATIONS ON CLOSELY SPACED RUNWAYS

KENNETH V. BYRAM (FAA, Washington, DC) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 71-79.

The paper discusses a precision runway monitor program aimed at reduction of the time it takes the radar to display a potentially hazardous situation ('blunder'), and the time it takes the controller to see it on the display and react to it. Two prototype versions of an improved radar utilizing the monopulse technique are outlined, and the demonstration program is discussed. Attention is focused on false alarms, runway misidentification, blunder geometry, turbulent conditions, obstruction evaluation, and control blunder resolution instructions. Operational implementation schedules are presented. V.T.

A90-46394#

THE MYTHOLOGY OF FIRST-COME-FIRST-SERVE LANDING ORDER

JERRY D. WELCH (MIT, Lexington, MA) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 93-98. Research sponsored by FAA.

The problem of definitions is first discussed, pointing out that the first-come criterion ideally should be defined as early as possible in the terminal area. The various factors influencing landing time are analyzed, including wind as a key limitation to manual ATC systems. It is noted that only TRACON controllers can predict landing time with enough certainty, however, in high-demand situations, controllers cannot consistently arrange arriving aircraft in first-come-first-serve order at any phase in the landing process. The introduction of computer aids into the terminal air-traffic control routine is proposed, specifically, in the area of arrival sequencing; such techniques can be incorporated in the Advanced Automation System. V.T.

A90-46396#

A MULTI-SENSOR APPROACH TO ASSURING GPS INTEGRITY

ALISON BROWN (Navsys Corp., Monument, CO) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 141-153. refs

The integrity requirements for existing radionavigation systems for different phases of flight, as well as integrity goals are outlined, and it is noted that the 100-m integrity alarm limit for GPS nonprecision approaches could be relaxed while still delivering equivalent or better performance to existing nonprecision approach navigation facilities. GPS integrity monitoring techniques such as a GPS integrity channel network, receiver autonomous integrity monitoring and its coverage are considered. Multisensor integrity monitoring is addressed with emphasis on GPS/baro-altitude aiding, GPS/inertial navigation systems, GPS/Loran-C, and GPS/GLONASS. The integrity requirements that can be met by the these multisensor GPS systems are presented, and it is concluded that the most promising multisensor system is a GPS/GLONASS receiver applicable to all flight phases. V.T.

A90-46398#

ADVANCED ARCHITECTURE FOR DOMESTIC AND GLOBAL AVIATION SYSTEMS

CLAYTON C. KORGEL (Martin Marietta Information Systems Group, Bethesda, MD) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 197-209.

Candidate elements for the future aviation systems are outlined, and top-down as well as bottom-up system architecture approaches are examined, and it is noted that automation and human factors will dominate the system including airspace and flight management subsystems. Communications systems, surveillance, and navigation and landing are discussed. Since the systems under consideration include possible synergisms, redundancies, and back-up capabilities, possible options and trade-offs are analyzed. Key technologies for future aviation systems such as the GPS/GLONASS integrated receiving set, real-time expert system/neural networks, antenna avionics, interactive speech and display processing, satellite communication equipment, and microwave monolithic integrated circuits are presented. V.T.

A90-46671

THE AIRBORNE SYNTHETIC CARTOGRAPHIC INDICATOR [L'INDICATEUR CARTOGRAPHIQUE SYNTHETIQUE AEROPORTE]

M. C. DISDERO (Sextant Avionique, Bordeaux, France) (Institut Francais de Navigation, Colloque Consacre a la Carte Electronique, Paris, France, Nov. 27, 1989) Navigation (Paris) (ISSN 0028-1530), vol. 38, July 1990, p. 332-338. In French. Copyright

The birth of the synthetic indications for charts (ICS) is due to new technologies, such as geographic military data bases, the capacity of the information storage, and the power of computation of the processors. The purpose of ICS is to increase the capability of pilots. An image of the geographical and tactical surrounding is given to them: a continuous display of the overflown areas, memorized items, and the capability to produce pictures in perspective. Author

A90-47657#

A NONLINEAR AIRCRAFT TRACKING FILTER UTILIZING CONTROL VARIABLE ESTIMATION

D. JOSEPH MOOK and IN-MING SHYU (New York, State University, Buffalo) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 771-781. refs (AIAA PAPER 90-3402) Copyright

This paper describes a filter for tracking both translational and angular position, velocity, and acceleration of a maneuvering aircraft, using remote sensor data. The approach taken is to develop a 16-state extended Kalman filter that estimates not only

the translational and rotational degrees of freedom but also the control variables (thrust and control-surface deflections). Improved force and moment models correlated to velocity, attitude angles, and control variables are utilized. Simulations of an F-4 fighter performing various maneuvers indicate improved tracking accuracy over conventional trackers as well as previous force-model trackers with less complete force models. Author

A90-47659*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

IMAGE BASED RANGE DETERMINATION

P. K. A. MENON and B. SRIDHAR (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 786-796. refs (Contract NCC2-575)

(AIAA PAPER 90-3404) Copyright

Flight vehicles operating at low altitudes such as rotorcraft require range determination schemes for locating the terrain and obstacles. The development of a ranging scheme combining image sequences from vehicle mounted passive imaging sensors and the vehicle motion variables obtained from an on-board inertial navigation system is described. This approach can handle sequences from more than one imaging device. Derivation of the numerical algorithm and the performance results using a laboratory image sequence are given. Other applications of the proposed approach include ranging schemes for autonomous planetary rovers and telerobots. Author

A90-47901

THE USE OF ONBOARD SENSOR DATA IN AERIAL TRIANGULATION - GPS, PRESSURE SENSORS, LASER TELEMTRY [UTILISATION DES MESURES SAISIES EN VOL EN AEROTRIANGULATION - GPS, CAPTEURS DE PRESSION, TELEMETRE-LASER]

CLAUDE MILLION (Institut Geographique National, Saint-Mande, France) Societe Francaise de Photogrammetrie et de Teledetection, Bulletin (ISSN 0244-6014), no. 118, 1990, p. 6-21. In French. refs Copyright

The French National Geographic Institute conducted nine experiments during the summers of 1986 and 1987 to evaluate the ability of airborne measurements to reduce the need for ground control in aerial triangulation (AT). AT with very dense ground control and check points was employed in all experiments as a basis of comparison to assess the accuracy of airborne measurement data. When the degree of accuracy reached was considered sufficient, these data were used as observations in the adjustment with photogrammetric measurements and reduced ground control. The third step was to eliminate all ground control points except one (when possible). In all three steps the results were assessed by computing the rms error on the check points. B.J.

A90-47909

AN INTEGRATED GPS/GLONASS RECEIVER

RAYMOND A. EASTWOOD (Magnavox Advanced Products and Systems Co., Torrance, CA) Navigation (ISSN 0028-1522), vol. 37, Summer 1990, p. 141-151.

Copyright

The advantages of utilizing an integrated GPS/GLONASS receiver are presented. Navigation data from the two similar but independent systems would assist in alleviating safety and integrity concerns for aircraft operators. The repetitive signals would allow the identification of faulty satellites and the substitution of satellites operating properly. A description is provided of a testbed receiver that was developed to conduct navigation, surveying, and time transfer experiments using satellite signals from both GPS and GLONASS. It is concluded that a dual receiver would reduce the integrity concerns for aircraft, allow navigation and surveying in rugged terrain, and permit more rapid surveying by faster lane

ambiguity resolution. Further details are provided for GLONASS and comparisons are made with GPS. R.E.P.

A90-48983

COMPUTERIZED MLS FLIGHT INSPECTION SYSTEM DEVELOPED

JACQUES PAUL DAVADANT (Service Technique de la Navigation Aérienne, Paris, France) ICAO Journal (ISSN 0018-8778), vol. 45, March 1990, p. 19-22.

Copyright

The French-developed flight inspection system for MLS, the new precision-guidance microwave landing system, was incorporated into a multifunction flight inspection system for radio navigation aids. The system performs measurements for navigational testing which require considerable computation capability onboard the research aircraft or special trajectory calculation equipment for flightpath determination. Current calculation capabilities will soon be improved, making possible measurements of such parameters as clearance indication, obstacle clearance limit, and relative levels of signals making up the MLS transmission sequence. The new calibration receiver developed for the French Technical Air Navigation Service is designed to allow these measurements to be performed. Typical flight profiles, measurements and checks performed, and special equipment needs both on ground and in air for reference trajectory calculations are discussed and results of testing are presented. L.K.S.

A90-49272#

POSSIBILITIES FOR IMPROVING TRAFFIC FLOWS [MOEGELICHKEITEN FUER DIE VERBESSERUNG VON VERKEHRSABLAEFEN]

T. KRUMNACK (Krupp Atlas Elektronik GmbH, Bremen, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 1, 1990, p. 124-128. In German.

The VIEWS (Visual Inspection and Evaluation of Wide-area Scenes) project to improve traffic flows is discussed. The components of the VIEWS system are outlined and the main areas of its application are examined. Selected examples of the project's activities in handling traffic at airports and on city streets are briefly considered. C.D.

A90-49490

1990-1995, A PERIOD OF INTERNATIONAL DECISION MAKING FOR THE NAVIGATION COMMUNITY - IS OUR PLANNING AS GOOD AS IT SHOULD BE?

R. JOHANNESSEN (STC Technology, Ltd., Harlow, England) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 15-18. refs
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A review of navigation systems, planning and decisions required for hyperbolic terrestrial navigation in Europe, GPS, GLONASS and GPS interoperability, GPS and INMARSAT, and Loran-C and geostationary satellites is presented. The major decisions these developments require to be made in the months to follow are summarized. In addition, means are suggested in which the international community can improve its navigation planning. R.E.P.

A90-49491#

AN ANALYSIS OF GPS RECEIVER PERFORMANCE CAPABILITIES AND TRENDS

KEITH D. McDONALD IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 19-30.

The changes that have occurred in GPS receivers during the past decade are analyzed. Operational classes of GPS receivers, with measurement accuracies for GPS survey receivers, channels versus year of receiver introduction, weight versus channels and year of introduction, and GPS survey receiver prices versus number of channels are described. Charts and tables provide an indication of the current status and future trends for the principal classes of survey receivers. R.E.P.

A90-49493#

THE FAA GEARS UP FOR LORAN

JOHN S. KERN (FAA, Washington, DC) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 53-57.

Measures that the FAA is taking to be prepared for the advent of full Loran operations in the National Airspace System are presented. Loran is an earth referenced navigation system as opposed to the station referenced navigation aids in current usage. An Early Implementation Program (EIP) was initiated in partnership with the National Association of State Aviation Officials (NASAO) to develop Loran nonprecision approaches at a small number of airports. The monitors employed for the EIP provided volumes of data on LORAN system performance, and they were also sources of design information for the operational monitors. The Loran system will affect practically all areas of the NAS including aviation standards, airways facilities, procedures development, flight inspection, and air traffic control. R.E.P.

A90-49494#

LORAN-C/GPS INTEROPERABLE COMPUTERIZED ALGORITHMS (LOGICAL)

JOHN C. CASTONIA (Illgen Simulation Technologies, Inc., Santa Barbara, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 61-70. refs

A simulation architecture and preliminary results for the investigation and relative comparison of GPS/Loran-C interoperable system architectures designed for the NAS are presented. The LOGICAL algorithms have been integrated to predict the effects on accuracy of system error contributions and failure modes in user-defined scenarios as needed. An overview of LOGICAL, a PC-based simulation, written in Turbo Pascal V5.0 is presented. The system integrates navigation algorithms replicating the GPS and Loran-C navigation systems, a scenario generation function, and a graphics generation feature into an expandable, modular architecture. R.E.P.

A90-49496

TOWARDS A QUANTITATIVE ASSESSMENT OF BENEFITS WHICH INS/GPS INTEGRATION CAN OFFER TO CIVIL AVIATION OPERATING IN A NON-JAMMING ENVIRONMENT

R. JOHANNESSEN (STC Technology, Ltd., Harlow, England) and M. J. A. ASBURY (Civil Aviation Administration, London, England) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 85-94.

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A methodology for assessing the value of particular combinations of GPS and INS with both feeding into a flight management system is proposed. The different combinations of GPS and INS sensors are analyzed using a typical trans-Atlantic crossing while considering certain operational demands and requirements. The distribution of outage durations are compared with the INS drift rates. Finally the quantification of the performance is discussed in terms of the probability that a particular requirement is not met. R.E.P.

A90-49497#

PHASE III GPS MANPACK RECEIVER OPERATION AND NAVIGATION PERFORMANCE

LARRY D. SYNSTELIEN and THEODORE C. DASS, III (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 95-104.

Performance data employing a precise positioning service authorized Manpack receiver in various practical land and air applications are presented. Specifications of the Manpack are described, and the receiver coordinates are compared to the coordinates of independently surveyed locations. The data show operations in environments with and without CW jamming. Results

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from live satellite tracking on Y-code with compensation for selective availability perturbations are included. Finally, performance data from a low dynamics flight environment are compared to results from VOR/DME navigation. R.E.P.

A90-49501#

CERTIFICATION IMPACT OF INTRODUCING G.P.S. INTO COMMERCIAL TRANSPORT NAVIGATION SYSTEMS

JOHN C. COTTON (Litton Aero Products, Moorpark, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 137-139.

A90-49503#

STRAPDOWN ASTRO-INERTIAL NAVIGATION (SAIN) UTILIZING THE OPTICAL WIDE-ANGLE LENS STARTRACKER (OWLS)

SEYMOUR LEVINE (Northrop Corp., Electronics Systems Div., Hawthorne, CA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 169-176.

Strapdown stellar inertial systems as autonomous, high precision navigators for manned aircraft, missiles, remote piloted vehicles, and ships are presented. It is pointed out that a great deal of the electro-optical machinery required to implement an effective inertial navigation augmentation system can also be utilized as a terminal or target sensor system. One augmentation mechanism for these dead reckoning strapdown inertial navigation systems is a strapdown solid state astrotracker. The combination of a strapdown inertial navigator with an astrotracker provides accurate autonomous navigation. Both SAIN and OWL navigation systems are described in detail. R.E.P.

A90-49675

A NEW METHOD OF AIRCRAFT MOTION ERROR EXTRACTION FROM RADAR RAW DATA FOR REAL-TIME MOTION COMPENSATION

JOAO R. MOREIRA (DLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, Federal Republic of Germany) (IEEE, Canadian Remote Sensing Society, URSI, et al., Quantitative remote sensing: An economic tool for the Nineties - 1989 International Geoscience and Remote Sensing Symposium and Canadian Symposium on Remote Sensing, 12th, (IGARSS'89), Vancouver, Canada, July 10-14, 1989) IEEE Transactions on Geoscience and Remote Sensing (ISSN 0196-2892), vol. 28, July 1990, p. 620-626. refs Copyright

A method for real-time motion compensation is presented. The method extracts all the necessary motions of the aircraft from the radar backscatter signal using a new radar configuration and new methods for evaluating the azimuth spectra of the radar signal. Hence an inertial navigation system becomes unnecessary for many applications. The motion-compensation parameters for real-time motion error correction are the range delay, the range-dependent phaseshift, and the pulse repetition frequency. The motions of the aircraft to be extracted are the displacement in line-of-sight direction, the aircraft's yaw and drift angle, and the forward velocity. Results show that a three-look image with an azimuth resolution of 3 m in L-band using a small aircraft is achievable, and the implementation of this method in real time using an array processor is feasible. I.E.

N90-26802#

Federal Aviation Administration, Atlantic City, NJ. **DALLAS/FORT WORTH SIMULATION, VOLUME 1** LLOYD HITCHCOCK, LEE E. PAUL, EPHRAIM SHOCHET, and RICHARD D. ALGEO Nov. 1989 124 p (Contract F2006C)

(DOT/FAA/CT-TN89/28-VOL-1) Avail: NTIS HC A06/MF A01

A series of dynamic, real-time, air traffic control simulations of selected aspects of the Dallas/Fort Worth (D/FW) Metroplex Air Traffic System Plan was conducted. Using D/FW controllers as subjects, the simulations provided an opportunity to evaluate proposed changes in area flow patterns and traffic management and to experience simultaneous approaches to the four parallel

runway configuration under consideration for D/FW. A detailed description of the objectives of the study and of the technical approach and test methods used, are given. In addition, the combined results of the study and conclusions are presented.

Author

N90-26803#

Federal Aviation Administration, Atlantic City, NJ. DATA LINK TEST AND ANALYSIS SYSTEM/ATCRBS TRANSPONDER TEST SYSTEM TECHNICAL REFERENCE

JOHN VANDONGEN May 1990 159 p

(Contract FAA-T2001-F)

(DOT/FAA/CT-TN90/7) Avail: NTIS HC A08/MF A01

Reference material for persons using the Data Link Test and Analysis System (DATAS) for testing Air Traffic Control Radar Beacon System (ATCRBS) transponders is provided. Included is a brief overall description of the DATAS, a brief description of the ATCRBS, a thorough description of how to operate the DATAS ATCRBS transponder analysis system (User Guide), a detailed description of the DATAS ATCRBS transponder analysis programs, and a thorough description of each of the transponder field tests.

Author

N90-26804*#

Illinois Univ., Urbana-Champaign. Dept. of Psychology. COGNITIVE REQUIREMENTS FOR AIRCRAFT NAVIGATION Ph.D. Thesis

ANTHONY J. ARETZ Mar. 1990 124 p Sponsored in part by AFIT, Wright-Patterson AFB, OH

(Contract NAG2-308)

(NASA-CR-186933; NAS 1.26:186933; AD-A22736; AD-E501239; AFIT/CI/CIA-90-011D) Avail: NTIS HC A06/MF A01 CSCL 17/7

A cognitive analysis of a pilot's navigation task is presented, and using this foundation, an experiment is described comparing a new map display, employing the principal of visual momentum, to the two traditional track-up and north-up approaches. The visual momentum display is based on the characterization of the pilot's navigation task as the maintenance of a cognitive link between two reference frames (RFs) -- the ego-centered reference frame (ERF) and the world-centered reference frame (WRF). The ERF corresponds to the pilot's forward view of the world and the WRF corresponds to a north-up geographic map. The new map display employs visual momentum by presenting the ERF, in the form of a perceptual wedge, in the context of a north-up map's WRF. An experiment was conducted to assess the different displays using licensed pilots to perform diverse navigation tasks in the context of computer simulated helicopter missions. As predicted, the data showed the advantage to a track-up map is its congruence with the ERF; however, the development of survey knowledge is hindered by the inconsistency of the rotating display. GRA

N90-26805#

Transportation Systems Center, Cambridge, MA. FAA LORAN EARLY IMPLEMENTATION PROJECT Final Report, Oct. 1984 - Sep. 1989

IAN G. MCWILLIAMS, FRANCIS J. COYNE, STEPHEN F. NUZZI, and FRANKLIN D. MACKENZIE Mar. 1990 174 p

(AD-A221866; DOT-TSC-FAA-90-1; DOT/FAA/SA-90/4) Avail: NTIS HC A08/MF A01 CSCL 17/7

The Early Implementation Project (EIP), was the initial step in the process of Loran integration into the National Airspace System (NAS). The EIP was designed to give the FAA and the Loran user community experience in the operational use of Loran. The success of the entire Loran aviation program, particularly the EIP, depended upon the active participation of many organizations inside and outside the FAA. The experience gained in the EIP has helped the FAA make the transition from the limited project to the fully operational system at airports around the country and general users operating with TSO standard receivers. The EIP also serves as a model for the introduction of the Global Positioning System (GPS) into the NAS during the 1990s. GRA

N90-27672# Federal Aviation Administration, Atlantic City, NJ.
FLIGHT SERVICE AUTOMATION SYSTEM, MODEL 1 FULL CAPACITY, NAS OPERATIONAL TEST AND EVALUATION INTEGRATION TEST PLAN

FRANCES A. MACKUSE and ROBERT F. HAVEL (Data Transformation Corp., Silver Spring, MD.) Aug. 1990 45 p (DOT/FAA/CT-TN90/4) Avail: NTIS HC A03/MF A01

The overall philosophy and approach for the National Airspace System (NAS) Operational Test and Evaluation (OT and E)/Integration Test of the Flight Service Automation System (FSAS) Model 1 Full Capacity (M1FC) are presented. The M1FC System consists of three subsystems: (1) the Aviation Weather Processor (AWP); (2) the Flight Service Data Processing System (FSDPS); and (3) the Automated Flight Service Station (AFSS). The integration requirements from the NAS Specifications (NAS-SS-1000), which will provide the basis for the OT and E/Integration testing of this particular subsystem, are discussed. This test plan addresses M1FC only, and does not address FSAS end-state interface requirements. The only interfaces to be tested are the Weather Message Switching Center (WMSC) and the National Airspace Data Interchange Network 1A (NADIN 1A), as outlined in the Master Test Plan (MTP). The M1FC is not designed to satisfy the end-state Area Computer Control Complex (ACCC), Weather Message Switching Center Replacement (WMSCR), National Airspace Data Interchange 2 (NADIN 2), Traffic Management Processor (TMP), or Maintenance Processor Subsystem (MPS) interfaces. These end-state interface requirements are included in the NAS System Specification, and Project Compliance Plans were written stating that these interfaces will be implemented as separate enhancement to M1FC. Author

N90-27673# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abt. Systemtechnik und Navigation.

POSITION FINDING AND GROUND TARGET DIRECTION FINDING BY AN AIRCRAFT WITH A GIMBALED VIDEO CAMERA Ph.D. Thesis - Tech. Univ. Brunswick

MAGNUS DRENGWITZ Jun. 1989 90 p In GERMAN; ENGLISH summary (DLR-FB-89-62; ISSN-0171-1342; ETN-90-97011) Avail: NTIS HC A05/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 33 DM

The accuracy of positioning and ground target aiming with a video camera in the Dornier 228 research aircraft is investigated. The video position is compared to the reference trajectory generated by the Avionics Flight Evaluation System (AFES). Systematic errors are identified on the basis of a nonlinear error model and the least squares fit method. Statistical analysis of the residues allows for a judgement about the accuracy of ground target aiming to be made. The correlation of measurements is shown to be important for the sampling frequency of an INS (Inertial Navigation System) update. ESA

N90-27674# Aeritalia S.p.A., Turin (Italy). Combat Aircraft Group.

EXPERT SYSTEM FOR PILOT ASSISTANCE: THE CHALLENGE OF AN INTENSIVE PROTOTYPING

PAOLO GALLO, DANILO DABBENE (CSI-Piemonte, Turin, Italy), FEDERICA LUISE, and PATRIZIA GIORDANENGO 1989 19 p Presented at Symposium on Artificial Intelligence as an Aid in Military Operational Decision-Making, Orlando, FL, 27-31 Mar. 1989; sponsored by International Society for Optical Engineering and IEEE Previously announced in IAA as A90-38909 (ETN-90-97274) Avail: NTIS HC A03/MF A01

The methodologies and techniques employed to develop an expert system for pilot assistance while performing route planning or replanning, the functional characteristics of a first prototype working on a Lisp machine, and its current architecture are presented. This prototype is able to provide the pilot with dynamic information about the geography of terrain, the tactical situation, the meteorological conditions and the current state of the aircraft; static information about threats characteristics, fuel consumption, aircraft configuration and pre-planned route are also available. The

system is able to plan complete ground attack missions and to suggest the most suitable push-up point for the run-in on target. The experiences gathered during the development of this prototype are summarized. ESA

N90-27675# Federal Aviation Administration, Atlantic City, NJ.
HELIPORT VISUAL APPROACH SURFACE HIGH TEMPERATURE AND HIGH ALTITUDE TESTS Technical Report, Apr. 1988

SUZANNE SAMPH, ROSANNE M. WEISS, and CHRISTOPHER J. WOLF May 1990 84 p (DOT/FAA/CT-TN89/34) Avail: NTIS HC A05/MF A01

Flight tests were conducted at an auxiliary landing field to examine the current heliport approach/departure surface criteria under hot climate and/or high altitude conditions and to verify or modify these surfaces, if appropriate. Data were collected using a Bell UH-1 helicopter for 7.125, 8.0, and 10.0 deg. straight-in approach surfaces. Also, straight-in departure surfaces of 7.125, 10.0, and 12.0 deg. were used. In addition to these procedures, the pilots were able to choose any angle of approach and departure. All maneuvers were tracked using an onboard Global Positioning System (GPS). The flight test and evaluation methodology are described. Also, technical as well as operational issues are presented. Statistical and graphical analysis of pilot performance along with a discussion of pilot subjective opinions concerning the acceptability and perceived workload, safety, and control margins associated with the procedures flown are also provided. Author

N90-27676# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung.

INTEGRATED AIR TRAFFIC MANAGEMENT

Dec. 1989 333 p Seminar held in Brunswick, Fed. Republic of Germany, 30-31 May 1989 LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by color photographs Original contains color illustrations (DLR-MITT-89-23; ISSN-0176-7739; ETN-90-97535) Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

The papers presented at the seminar on the integrated Air Traffic Management (ATM) are reported. The major areas covered by the research programs are: operational aspects, ground based components and procedures, onboard components, air-ground-air communication, requirements for future ATM systems, data link applications, navigation aid and flight management systems, airport ground movement simulator, and coordination program for multidisciplinary activities in the field of ATM.

N90-27677# Technische Univ., Berlin (Germany, F.R.).
AIR TRAFFIC MANAGEMENT IN EUROPE: STRUCTURE, TASKS, POTENTIAL

H. MENSEN /n DLR, Integrated Air Traffic Management 15 p Dec. 1989 Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

The Air Traffic Management (ATM) system is to be defined. The components and interfaces are described. The current situation in air transportation is characterized by an increasing traffic volume, more and more beyond the capacity limits of the present Air Traffic Control (ATC) system. To increase the available capacity the ATC system of the future is to be understood as a part of the ATM. This applies to air traffic flow management optimizing the usage of the available resources regarding the components of the air traffic system, the ATC, and the airspace users. ESA

N90-27678# Deutsche Lufthansa A.G., Hamburg (Germany, F.R.).

AIRLINE REQUIREMENTS FOR A FUTURE AIR TRAFFIC MANAGEMENT SYSTEM

J. VOIGT /n DLR, Integrated Air Traffic Management 18 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

Airline requirements for an Air Traffic Measurement (ATM) system are discussed. To meet the challenges of the future the efficiency and the capacity of the Air Traffic Control (ATC) system must be increased. New technologies, a higher degree of automation in ATC equipment and an adequate number of highly qualified and motivated staff are required. An efficient and cost effective system capable of coping with future demands is needed. The ultimate objective must be the establishment of a common European air traffic control organization with full authority from its member states for the planning, implementation and operation of the new ATM system. ESA

N90-27679# Bundesanstalt fuer Flugsicherung, Frankfurt am Main (Germany, F.R.).

R AND D ASPECTS OF THE FUTURE OPERATIONAL CONCEPT OF THE BFS

K. PLATZ *In its* Integrated Air Traffic Management 18 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

A new operational concept for Air Traffic Control (ATC) system is described. The ATC system of the future must satisfy the requirements and be able to cope with demand. Some aspects of the capacity, the components of the operational concept for the future system are described. The system is to be used as a guideline for the evolutionary development. The major areas for research work are given. The activities in the navigational field, air traffic management service, air traffic flow management, and monitoring are underlined. A concept for the replacement of the printed control strips is evaluated. ESA

N90-27680# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

ON-BOARD PLANNING AND CONTROL OF 4D-TRAJECTORIES IN THE TMA

VOLKMAR ADAM *In its* Integrated Air Traffic Management 24 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

An automatic four dimensional guidance function available in future advanced Flight Management Systems (FMS) is described. An FMS function for the four dimensional guidance in the Terminal Maneuvering Area (TMA) from a Metering Fix to the Merge Gate was developed and flight tested. The four dimensional guidance concept is based on usual radar vector guidance technique of air traffic control. The four dimensional guidance function and results from flight tests with the NASA Boeing B737 test aircraft are presented. ESA

N90-27681# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Hamburg (Germany, F.R.).

FOUR-DIMENSIONAL NAVIGATION AND FLIGHT MANAGEMENT SYSTEMS

L. KILCHERT *In its* Integrated Air Traffic Management 15 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

Th four dimensional navigation available on new aircraft is described. In order to ease airspace congestion it is necessary to keep aircraft in the air only the minimum time required to perform the intended mission. To achieve this the takeoff time, routing and speed schedule has to be a function of available landing time and individual aircraft capability. The implementation on B737 and A320 Flight Management Systems (FMS) is presented. ESA

N90-27682# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

ON THE STRUCTURE OF A FUTURE FLIGHT OPERATIONS SYSTEM

J. REICHMUTH *In its* Integrated Air Traffic Management 24 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

The structure of a future interface between cockpit crew and aircraft is presented. The elements needed by such a Flight Operations System (FOPS) are discussed. The new concepts integrating mental models of pilot and human information technologies are considered. The new system allows man and machine to negotiate about common goals rather than on machine functions. This communication model requires a high level of system flexibility. It handles parallel interpreter modules like natural language interpreter in operation with eyepoint-of-regard-measurements and precompiled modules like emergency or normal aircraft operation procedures. ESA

N90-27683# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

FOUR-DIMENSIONAL PLANNER: A GROUND BASED PLANNING SYSTEM FOR TIME ACCURATE APPROACH GUIDANCE

D. DIPPE *In its* Integrated Air Traffic Management 24 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

The (four dimensional) 4D-Planner is a ground based planning system, destined to assist the Air Traffic Control (ATC) controller in the time accurate approach guidance of poorly equipped aircraft in a future time based air traffic environment. The necessary data sources and prerequisites to calculate optimal time accurate profiles are explained. The role of the human controller is discussed. The best use of the planning data and the tasks he has to perform are considered. Some ideas of a user friendly man-machine interface are shown. ESA

N90-27684# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

DEVELOPMENT OF A COMPAS PROTOTYPE FOR THE ATC CENTRE AT FRANKFURT (FED. REPUBLIC OF GERMANY)

H.-D. SCHENK *In its* Integrated Air Traffic Management 22 p Dec. 1989 Original contains color illustrations

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

The design and development of an operational Computer Oriented Metering, Planning and Advisory System (COMPAS) are reported. The work required to transfer the results of an experimental COMPAS developed earlier into an operational COMPAS is summarized. To identify relevant operational requirements and to implement an efficient human interface between COMPAS and the air traffic controllers are necessary. ESA

N90-27685# Technische Univ., Brunswick (Germany, F.R.).

SAFETY NET FUNCTIONS

P. FORM *In its* Integrated Air Traffic Management 21 p Dec. 1989 Original contains color illustrations

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

Safety net functions, which discover potentially dangerous traffic situations and even collision threats with very high probability, are considered. Conflict alert systems on the ground and collision avoidance systems in the air are described. Particular attention was given to the design of these systems with respect to false alarm rates and induction of problem situations. ESA

N90-27686# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

APPROACH TOWARDS A FUTURE INTEGRATED AIRPORT SURFACE TRAFFIC MANAGEMENT

U. VOELCKERS *In its Integrated Air Traffic Management* 19 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

A general concept of modular design for a ground control system is set up. The air traffic control system is in need of improved airport surface traffic control system. Any new system must be an integral part of the overall future air traffic management system. All aspects of arrival and departure flow control as well as airport facilities management have to be considered, in order to allow safe and efficient ground operations of aircraft. A new operational concept under development is presented. It necessitates new solutions in hardware or software functions and a new design of the ground controller's working environment.

ESA

N90-27687# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

EXPERIMENTAL STUDY TOWARDS A FUTURE AIRPORT GROUND MOVEMENT SIMULATOR

R. BEYER *In its Integrated Air Traffic Management* 30 p Dec. 1989 Original contains color illustrations

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

The Air Traffic Management and Operations Simulator (ATMOS) complemented by a Ground Movement Simulator (GMS) for taxiing aircraft and vehicles is presented. In preparation of this development experimental studies were made to explore crucial topics like a workstation based concept, network communication, voice recognition, visualization of taxiing aircraft and a ground movement planning system. The results presented support the specification of the planned GMS.

ESA

N90-27688# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

ASPECTS OF DATA LINK APPLICATIONS FOR ATC PURPOSES

W. GERLING *In its Integrated Air Traffic Management* 29 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

Significant changes in Air Traffic Control (ATC) systems and procedures are required for the near future in order to guarantee safety and regularity of air traffic operations. The application of computer based planning and advisory systems for strategical and tactical control together with a higher degree of automation are also required. Aircraft equipment and capabilities must be adequately adapted. In this future ATC environment the existence of digital data link capacity between ground and air will be a prerequisite for an efficient use of ATC planning and flight management systems and for automated functions. Potential data link applications are described in the context of the essential elements of a future ATC conception.

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N90-27689# Deutsche Lufthansa A.G., Hamburg (Germany, F.R.).

APPLICATION OF A COMPANY DATA LINK AT LUFTHANSA GERMAN AIRLINES

B. STEGEMPER *In DLR, Integrated Air Traffic Management* 22 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

Effective air traffic management is highly dependent upon the information flow between all participants. The introduction of Datalink which connects ground based and airborne electronic

data processing (EDP) is described. The main kinds of transmitted data are airline administrative communication, airline operational control and air traffic services related. The motivation for Lufthansa to install a Datalink system is justified. Possible improvements and extensions for Datalink are considered.

ESA

N90-27690# Eurocontrol Agency, Brussels (Belgium).

PHARE: CONCEPT AND PROGRAMME

B. KIRSTETTER *In DLR, Integrated Air Traffic Management* 23 p Dec. 1989

Avail: NTIS HC A15/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 105 Deutsche marks

Future developments of the Air Traffic Management (ATM) system are investigated. The concept descriptions produced during the studies of ATM requirements are summarized. The need for the integration of automated systems on the ground and in the air is justified. The program PHARE was set up to draw together and coordinate ongoing and planned research activities in the field of air traffic control, avionics and human factors. PHARE objectives, multidisciplinary activities and obtained results are summarized.

ESA

N90-27691# Research Inst. of National Defence, Stockholm (Sweden). Dept. of Weapon Systems, Effects and Protection.

A STUDY OF TERRAIN FOLLOWING SYSTEMS AND THE CREATION OF FLIGHT PATHS FOR TERRAIN FOLLOWING VEHICLES

ROLF ANDEMARK and SVEN-LENNART WIRKANDER Dec. 1989 141 p In SWEDISH; ENGLISH summary

(FOA-C-20774-2.5; ISSN-0347-3694; ETN-90-97095) Avail: NTIS HC A07/MF A01

The need for adequate paths for different vehicles was studied. Different types of threats and strategies were taken into account around an anti-aircraft defended area. The flight paths for these terrain following vehicles, from strategic bombers to remotely piloted vehicles, must follow the terrain as closely as possible and must be within the dynamic limitations (as acceleration and flight velocity) of these vehicles. A literature survey is presented and one of the documents included a very valuable theoretical background. This work was the foundation for the development of a computer model that optimized a flight path over a given terrain by linear programming techniques.

ESA

N90-27693# Royal Aerospace Establishment, Farnborough (England). GARTEUR Action Group FM(AG)03.

INTEGRATION OF FLIGHT MANAGEMENT AND AIR TRAFFIC MANAGEMENT SYSTEMS Final Report

Feb. 1990 41 p

(RAE-TM-FM-41; BR113246; ETN-90-97527; AD-A221696)

Copyright Avail: NTIS HC A03/MF A01

GARTEUR Action Group FM(AG)03 was set up in late 1984 to consider how airborne flight management system and the equivalent ground based Air Traffic Management System (ATM) could work together to form a genuine integrated ATM system. A particular problem was how best to utilize the airborne precision four dimensional navigation capability that was moving from the experimental realm to airline adoption. The resulting concept of a computer based strategic ATM system utilizing four dimensional trajectories with defined tolerances has become known as the GARTEUR four dimensional tubes in space concept. These concepts were developed through a series of publications and have proved to be very influential in shaping the thinking of groups such as the International Civil Aviation Organization Future Air Navigation System (FANS) committee and the PHARE (Programme of Harmonized ATM Research in the Eurocontrol Organization (Eurocontrol)) European experimental ATM programs. The group's activities are described and recommendations for the work of a successor group are given.

ESA

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-45881#

FLIGHT TESTS WITH A NATURAL LAMINAR FLOW GLOVE ON A TRANSPORT AIRCRAFT

K. H. HORSTMANN, G. REDEKER, A. QUAST (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), U. DRESSLER, and H. BIELER (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 385-392. refs
(AIAA PAPER 90-3044) Copyright

A laminar flow characteristics flight test program has been conducted with a wing glove designed to separately obtain the Tollmien-Schlichting instability, the crossflow instability and attachment-line transition over the 0.35-0.7 Mach number and 12 to 30 million Reynolds number ranges. The entire transition line is rendered visible by IR imaging, and pressure distributions applicable to stability analyses were obtained. An extensive data base for transition predictions by stability calculations at large Reynolds numbers is therefore available. Attachment-line results have been obtained which are in good agreement with the Pfenninger-Poll criterion. O.C.

A90-46002

VTOL MILITARY RESEARCH AIRCRAFT

MIKE ROGERS New York, Orion Books, 1989, 248 p.
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A comprehensive development history is presented for the range of experimental VTOL aircraft whose lessons have led to the successful creation of the AV-8B Harrier fighter, Yak-38 Forger fighter, and V-22 Osprey tactical transport/troop assault aircraft. These thrust-vectoring and tilt-rotor configurations were arrived at through a lengthy process of elimination in which the flight testing of numerous powerplant/airframe configurations established comparative performance and cost-effectiveness levels. The configurations thus considered encompassed wing-buried fans, tilt-wings, tilt-rotors, deflected thrust, vectored thrust, augmented lift-jets, tilt-jets, and both turboprop and turbojet tail-sitters. O.C.

A90-46385* AS&M, Inc., Hampton, VA.

THE DESIGN OF A LOW REYNOLDS NUMBER RPV

S. SIDDIQI, R. EVANGELISTA (AS&M, Inc., Hampton, VA), and T. S. KWA (Aviation Advanced Technology Applications, Orlando, FL) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 381-393. refs
(Contract NAS1-18599)
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This paper covers the ongoing design process for a long endurance Remotely Piloted Vehicle (RPV). The 45-pound RPV must operate in the 25-50 knot speed range at low altitudes. Specially designed low-Reynolds number airfoils were used for efficient aerodynamics. A wing of AR = 23 was selected which will give an estimated L/D(max) of 27. Wing tip feathers will be used to reduce the induced drag. A comparison between the computed aerodynamic predictions and wind tunnel results is given. The predicted handling quality and performance results are given.

Author

A90-46386

CAPTIVE CARRY TESTING OF REMOTELY PILOTED VEHICLES

ALVIN CROSS (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: Low Reynolds number aerodynamics;

Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 394-406.

Copyright

Captive-carry testing on the Joined Wing LAURA (Low Altitude/Airspeed Unmanned Research Aircraft) is described. A flight worthy configuration was achieved. This is characterized by + 8 deg incidence on the main wing, + 5 deg incidence on the rear wing, winglet extensions, elevon extensions, aft fuselage strakes, and wing-juncture fences. K.K.

A90-46387

FLIGHT TESTING NAVY LOW REYNOLDS NUMBER (LRN) UNMANNED AIRCRAFT

RICHARD J. FOCH and PEGGY L. TOOT (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: Low Reynolds number aerodynamics; Proceedings of the Conference, Notre Dame, IN, June 5-7, 1989. Berlin and New York, Springer-Verlag, 1989, p. 407-417.

Copyright

The development of small unmanned aircraft utilizing state-of-the-art advances in LRN aerodynamics for use in U.S. Navy electronic warfare missions is discussed. Particular attention is given to two missions. The first requires a long-endurance low-speed low-altitude vehicle while the second requires a short-endurance low-speed low-altitude vehicle. The development of the Low Altitude/Airspeed Unmanned Research Aircraft (LAURA) is discussed. K.K.

A90-46479

STIFFNESS OF AN AIRCRAFT PNEUMATIC RUDDER DRIVE [O ZHESTKOSTI RULEVOGO PNEVMATICHESKOGO PRIVODA LETATEL'NOGO APPARATA]

A. B. KONDRAT'EV and V. A. CHASHCHIN Aviaatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 7-10. In Russian.
Copyright

A pneumatic rudder drive system is examined which features an amplifier of the jet tube type and a pneumatic power cylinder. Parameters are identified which determine the static and dynamic stiffness of the drive. The relationship between the stiffness characteristics of the drive and its dynamics and resonance characteristics is examined. V.L.

A90-46480

EFFECT OF THE DRAG ON THE CRITICAL FLUTTER VELOCITY [VLIANIE LOBOVOI NAGRUIZKI NA KRITICHESKUII SKOROST' FLATTERA]

V. A. PAVLOV, V. G. GAINUTDINOV, and I. M. LEBEDEV Aviaatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 10-13. In Russian. refs
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An algorithm is proposed for constructing linearized matrix equations of equilibrium for a deformed lifting surface. The critical generation rate of nonattenuating vibrations in flow over a wing loaded by a drag force is calculated numerically. Results of an experimental study of the aeroelastic instability of a lifting surface are presented. V.L.

A90-46485

THE PROBLEM OF AIRCRAFT TEST FLIGHT CORRECTION [O ZADACHE KORREKTSII ISPYTATEL'NOGO POLETA. SAMOLETA]

V. A. TALYZIN and A. IU. ALEKSANDROV Aviaatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 29-33. In Russian.
Copyright

The problem of mission correction for an aircraft test flight is stated and reduced to that of discrete programming with an objective function in the form of a combination of additive and multiplicative components. The problem is then solved using the successive optimization approach. A number of theorems are presented which make it possible to significantly simplify the solution. V.L.

A90-46499

EVALUATION OF THE DYNAMIC CHARACTERISTICS OF A HELICOPTER INSTRUMENT PANEL [OTSENKA DINAMICHESKIKH KHARAKTERISTIK PRIBORNOI DOSKI VERTOLETA]G. V. KOSTIN, N. N. KUZNETSOVA, and V. N. IAGODKIN
Aviatsionnaya Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 83, 84. In Russian.

Copyright

The vibrodynamic characteristics of the left-hand instrument panel of the Mi-8T helicopter were investigated as part of a program aimed at improving the working conditions of helicopter crews. The experimental evaluation of the vibrodynamic characteristics of the instrument panel was carried out using a multiple-input model. In contrast to the classical one-dimensional model commonly used in the analysis of vibration isolation systems, the use of a multiple-input model makes it possible to account for vibrations in different directions and statistical relations between the vibration components. Ways of reducing the vibrations of the instrument panel are discussed. V.L.

A90-46618

OPTIMUM AIRCRAFT DESIGN: MULTIPURPOSE APPROACH [OPTIMAL'NOE PROEKTIROVANIE LETATEL'NYKH APPARATOV: MNOGOTSELEVOI PODKHOD]

VLADIMIR S. BRUSOV and SERGEI K. BARANOV Moscow, Izdatel'stvo Mashinostroenie, 1989, 230 p. In Russian. refs

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An approach to optimum aircraft design is presented which is based on the idea of combining the universal (multipurpose) nature of aircraft possibilities with the limited (specialized) use of these possibilities in aircraft system functioning. An optimum design model for multipurpose aircraft systems is formulated, and methods of assessing the efficiency of such systems are examined. The possibility of substituting simplified conditions for the set of aircraft operation conditions is discussed; optimization algorithms are presented. V.L.

A90-46926

VERTICAL LIFT AIRCRAFT DESIGN CONFERENCE, SAN FRANCISCO, CA, JAN. 17-19, 1990, PROCEEDINGS

Conference sponsored by AHS and NASA. Alexandria, VA, American Helicopter Society, 1990, 352 p. For individual items see A90-46927 to A90-46951.

Topics presented include an overview of the NASA High Speed Rotorcraft Technology Development Program, propulsion system design for supersonic STOVL aircraft, NASA studies on hot gas ingestion and ground effects on STOVL aircraft, and the V/STOL transport concepts for special operations. Also presented are fault-tolerant architecture for a fly-by-light flight control computer, the servo flap in an advanced rotor control system, the high-speed rotorcraft V/STOL, and the improvement to interactive two-dimensional rotor section design. Also contributed are the experimental investigation of wingtip aerodynamic loading, the performance of an optimized rotor blade at off-design flight conditions, an unmanned air vehicle concept with tipjet drive, and AH-64A Apache hydraulic flight control system survivability design concepts. R.E.P.

A90-46935#

SELF-RETRACTING HELICOPTER RESCUE HOIST

R. H. HOLLROCK (Kaman Aerospace Corp., Bloomfield, CT) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 10 p.

A self-retracting rescue hoist has been designed and was installed in the Kaman YSH-2G Demonstrator Navy helicopter. The hoist system will be included in the new Navy SH-2G helicopters. The retractable rescue hoist boom folds into the unused space between the bulkhead aft of the pilot's seat and the sliding door. There is no obstruction to cabin entry or cabin seating, whether the boom is deployed or stowed. The hoist is unique in operation since the hoist winch itself is used for extension and

retraction. The extended hoist boom locates the hook high above the doorway opening, which is best for rescue operations and yet retracts completely for a zero drag increment. The system could be applied to future high speed helicopters and VTOLs that are to be used for rescue missions. Author

A90-46936*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

METHODOLOGY FOR ESTIMATING HELICOPTER PERFORMANCE AND WEIGHTS USING LIMITED DATA

CLAUDIO BASERGA, CHARLES INGALLS, HENRY LEE, and RICHARD PEYRAN (NASA, Ames Research Center; U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 41 p. refs

Methodology is developed and described for estimating the flight performance and weights of a helicopter for which limited data are available. The methodology is based on assumptions which couple knowledge of the technology of the helicopter under study with detailed data from well documented helicopters thought to be of similar technology. The approach, analysis assumptions, technology modeling, and the use of reference helicopter data are discussed. Application of the methodology is illustrated with an investigation of the Agusta A129 Mangusta. Author

A90-46937#

MODELLING ASPECTS FOR THE SYNTHESIS AND PERFORMANCE ASSESSMENT OF SOME FUTURE ADVANCED HELICOPTERS

C. E. CATCHPOLE (Westland Helicopters, Ltd., Yeovil, England) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 11 p.

Development of compound helicopter models from conventional rotorcraft models, with a view into the potential that compound craft may offer, is presented. In developing a synthesis model, consideration has been given to lifting devices including blowing options and the augmentor wing. Propulsion devices including variable nozzles, the zero stage fan, the variable pitch fan, and mixed flow powerplants are also considered. The developed model shows a 28 percent saving in mass for a compound using a mechanically flapped wing and a variable pitch ducted fan over the typical helicopter for a specific mission. Additional model results indicate that a speed requirement (about 180 knots for this study) exists, above which a compound vehicle offers a lighter solution than a conventional helicopter. R.E.P.

A90-46938#

HIGH-SPEED ROTORCRAFT V/STOL - AN INITIAL ASSESSMENT

JOHN SCHNEIDER and JOSEPH WILKERSON (Boeing Helicopters, Philadelphia, PA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 20 p. refs

This paper reports on the first task of the NASA-contracted study of 'Technology Needs for High-Speed Rotorcraft'. Initially, some 15 to 20 concepts were defined for a comparative evaluation. The five most attractive concepts were selected for mission analysis and more detailed conceptual definition. This provided the data for assessment and recommendation of two concepts for the technical evaluation in Task II. Alternative propulsion systems were also considered for application as appropriate to the aircraft concepts. Author

A90-46939#

CTR-1000 CIVIL TILTROTOR CONCEPT

RODNEY S. TAYLOR (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 14 p.

This paper presents the process of conceptual design in response to a hypothetical RFP for a civil aircraft to support offshore

oil rigs. A derivative of a concept developed earlier was found to be capable of meeting the RFP requirements with minimum penalties. The paper illustrates the step-by-step process and discusses the possibility of several tradeoffs. The resultant concept is fully responsive to the RFP requirements. A summary specification for the concept appears at the end of the paper.

Author

A90-46940#

MISSION PERFORMANCE COMPARISON BETWEEN TILT ROTOR, VARIABLE DIAMETER TILT ROTOR AND TILT WING AIRCRAFT

MARK W. SCOTT (Sikorsky Aircraft, Stratford, CT) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 7 p.

The tilt-rotor concept has proven to be the most successful high speed rotorcraft to date; however, compared to a helicopter, its payload is reduced at short to medium ranges. The performance advantages of a variable diameter tilt rotor and a floating wing tilt-rotor are presented in terms of payload-range capability and productivity. Parametric weight and classical aerodynamic analyses are used to estimate the performance of these two configurations in comparison with a conventional tilt-rotor. Payload increases on the order of 30 percent to 37 percent and productivity increases on the order of 15 percent to 18 percent appear to be achievable for the same installed power.

Author

A90-46944#

GTPDP - A ROTARY WING AIRCRAFT PRELIMINARY DESIGN AND PERFORMANCE ESTIMATION PROGRAM INCLUDING OPTIMIZATION AND COST

DANIEL P. SCHRAGE, DIMITRIS N. MAVRIS, and MARK WASIKOWSKI (Georgia Institute of Technology, Atlanta) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 19 p. refs

The Georgia Tech Preliminary Design and Performance Program (GTPDP) research objective is to develop a simple, rapid, and reliable analytical method for carrying out helicopter preliminary design and performance analysis for utilization in rotorcraft design courses and independent design assessments. Flight test data and predictions are compared for three rotorcraft (YAH-64, CH-3E and HH-53C) in different weight categories. The designed code is based on the original single rotor helicopter design and performance program codes. It is concluded that good correlations are achieved between predicted and measured results and that the developed code can be used to predict the behavior of a given helicopter with adequate accuracy.

R.E.P.

A90-46946*#

ANALYTICAL SERVICES AND MATERIALS, INC., HAMPTON, VA. PERFORMANCE OF AN OPTIMIZED ROTOR BLADE AT OFF-DESIGN FLIGHT CONDITIONS

ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA) and HENRY JONES (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 14 p. refs

An investigation is made of the dynamic and aerodynamic performance of a helicopter rotor previously optimized for minimum 4/rev vertical shear and blade weight subject to certain dynamic and structural constraints. The program CAMRAD which was used in designing the optimized blade is used for both dynamic and aerodynamic analysis. The behavior of the optimized rotor is analyzed over a wide range of operating conditions and for a larger number rotor characteristics than those considered in designing the blade. To assess the dynamic behavior, the blade root vibratory shears and moments that are transmitted to the rotor hub are calculated. The aerodynamic performance assessments are made based on the power required by the rotor for a given rotor task, the rotor lifting efficiencies, maximum rotor

thrust envelopes and the control margins. Results are presented for the optimized blade and the reference blade which was used as the baseline for the optimized blade, for two rotor tasks.

Author

A90-46950*#

National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. AERODYNAMIC DESIGN OF THE CAL POLY DA VINCI HUMAN-POWERED HELICOPTER

SCOTT LARWOOD (NASA, Ames Research Center, Moffett Field, CA) and NEAL SAIKI (California Polytechnic State University, San Luis Obispo, CA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 19 p. refs

This paper will discuss the methodology used in designing the rotor and drive propellers for the third generation Cal Poly Da Vinci Human-Powered Helicopter. The rotor was designed using a lifting surface, uniform inflow hover analysis code and the propeller was designed using a minimum induced-loss method. Construction, geometry, and operating considerations are discussed as they impact the designs. Optimization of the design performance is also explained. The propellers were tested in a wind tunnel and results are compared with theoretical data. Successful flight tests of the Da Vinci III are discussed.

Author

A90-46951#

AN UNMANNED AIR VEHICLE CONCEPT WITH TIPJET DRIVE

ALAN W. SCHWARTZ, KENNETH R. READER, and ERNEST O. ROGERS (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 12 p. refs

A new concept is developed for an unmanned aerial vehicle (UAV) configured with a tipjet-driven, two-bladed, stoppable rotor and circulation control airfoils. The vehicle's high-aspect ratio wing 'converts' to a tipjet-driven helicopter rotor for vertical takeoff and landing (VTOL). The conceptual design is presented for a 1200-lb Tipjet VTOL UAV that is suitable for performing various Navy UAV missions. Vehicle performance predictions are included for the key flight regimes of hover, low-speed rotary-wing flight, and conversion between rotary-wing and fixed-wing flight. Test results of the proposed duct/nozzle configuration validate the pneumatic performance assumptions used in the conceptual design. A technology development program is outlined, along with tests of model and full-scale hardware, to support the timely fielding of a Tipjet VTOL UAV system. Results of standard mission performance analyses indicate that the 1200-lb Tipjet VTOL UAV is a viable candidate vehicle for the designated Navy UAV missions. Moreover, the Tipjet concept is directly applicable to much larger UAVs that will greatly enhance naval warfare capabilities.

Author

A90-46952

AHS NATIONAL SPECIALISTS' MEETING ON ROTORCRAFT DYNAMICS, ARLINGTON, TX, NOV. 13, 14, 1989, PROCEEDINGS

Alexandria, VA, American Helicopter Society, 1989, 426 p. For individual items see A90-46953 to A90-46976.

Various papers on rotorcraft dynamics are presented. Individual topics addressed include: aeromechanical stability of helicopters, evolution and test history of the V-22 Aeroelastic Model Series, helicopter individual blade control through optimal output feedback, dynamic characteristics of composite beam structures, dynamic testing of thin-walled composite box beams in a vacuum chamber, fundamental dynamics issues for comprehensive rotorcraft analyses, and development of the second generation Comprehensive Helicopter Analysis System. Also considered are: experiences in NASTRAN airframe vibration predictions, application of CRFD program to total helicopter dynamics, vibration reduction on servoflap controlled rotor using HHC, V-22 MSC/NASTRAN airframe vibration analysis and correlation, responses of helicopter rotors to vibratory airloads, helicopter rotor load calculations,

prediction and alleviation of V-22 rotor dynamic loads, free wake analysis of rotor configurations for reduced vibratory airloads.

C.D.

A90-46953#

PERSPECTIVES IN AEROMECHANICAL STABILITY OF HELICOPTER ROTORS

INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 58 p. refs

The aeromechanical stability of a helicopter rotor, including pitch-flap, flap-lag, and ground and air resonance, is reviewed for articulated, hingeless, and advanced rotor systems, including bearingless, circulation control, and composite rotors. Analysis methods (such as calculations of vehicle trim, rotor steady response, and stability of perturbation of motion), various aerodynamical stability phenomena, and both structural and aerodynamic mathematical modeling of blades are discussed. It is recommended that nonclassical effects such as cross-sectional warping and transverse shear be considered in order to improve the structural modeling of composite blades. It is also stated that stability prediction in forward flight can be enhanced by incorporation of unsteady aerodynamics and wake modeling, that validation studies must be expanded to cover forward flight and advanced rotor configurations, and that the domain of aeromechanical stability studies must be broadened to cover maneuvering flight.

L.K.S.

A90-46954#

EVOLUTION AND TEST HISTORY OF THE V-22 0.2-SCALE AEROELASTIC MODEL

T. BEN SETTLE and DAVID L. KIDD (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 30 p.

Model construction and ground and wind tunnel test experiences are discussed for several variants of the C901 0.2 Froude-scaled aeroelastic semispan and fullspan models of the V-22 multission tiltrotor aircraft being developed for the Navy. The testing occupied a five-year period from mid-1983 through mid-1988, and consisted of extensive ground testing and 46 weeks of wind tunnel testing of seven entries in three different wind tunnels. Model theory and construction techniques are reviewed and test plans, purposes, and results are examined. Schedule and model parameters are included.

L.K.S.

A90-46955#

APPLICATION OF A GENERAL-PURPOSE MECHANICAL SYSTEMS ANALYSIS CODE TO ROTORCRAFT DYNAMICS PROBLEMS

ANDREW S. ELLIOTT (McDonnell Douglas Helicopter Co., Mesa, AZ) and JAMES B. MCCONVILLE (Mechanical Dynamics, Inc., Ann Arbor, MI) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 12 p. refs

By comparison to closed-form solutions and other numerical solutions, a general-purpose dynamic system simulation code, ADAMS, is shown to be both capable of and appropriate for time domain analysis of helicopter rotor dynamics. All nonlinear geometric and kinematic effects are accounted for with no restriction on angular sizes or rates. Hardware components are modeled in a physically intuitive manner. The equations of motion are generated numerically and assembled automatically. Reaction forces at all internal connections are automatically retained in the analysis, greatly reducing post-processing requirements. This type of analysis is most appropriate for nonstandard rotor problems, such as bearingless, tilting or folding rotors, and maneuvering flight, where the geometric and kinematic assumptions implicit in typical rotor codes become invalid.

Author

A90-46958*# Maryland Univ., College Park.

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE AEROELASTIC STABILITY OF AN ADVANCED BEARINGLESS ROTOR IN HOVER AND FORWARD FLIGHT
JAMES M. WANG, INDERJIT CHOPRA, D. K. SAMAK, MICHAEL GREEN (Maryland, University, College Park), and TODD GRAHAM (NASA, Ames Research Center, Moffett Field, CA; Maryland, University, College Park) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 17 p. refs

(Contract NAG2-409; DAAG29-83-K-0002)

The aeroelastic stability of a shaft-fixed, 1/8th Froude scaled bearingless rotor was investigated in a series of wind tunnel experiments simulating a wide range of operating conditions. A finite element formulation was used to perform a parallel theoretical analysis, with the goal of determining whether a bearingless rotor system could be made aeroelastically stable without the incorporation of auxiliary dampers. A quick estimate of lag mode damping was provided by a refined moving-block analysis implemented in real time which predicted similar damping values. Model rotor and blade properties were also determined, and these properties were used as inputs for a newly refined bearingless rotor analysis. Predicted results were compared with experimental results in hover and forward flight. Results indicated that soft pitch link stiffness increases pitch-lag coupling and stabilizes lag mode stability in hover and at low advance ratios, but destabilizes at higher advance ratios.

L.K.S.

A90-46961#

FUNDAMENTAL DYNAMICS ISSUES FOR COMPREHENSIVE ROTORCRAFT ANALYSES

GENE C. RUZICKA and ROBERT A. ORMISTON (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 21 p. refs

The analysis of rotorcraft dynamics is examined from the perspective of modern computational mechanics methodologies such as finite element analysis and multibody dynamics, noting that the development of effective rotorcraft analysis software will likely depend on these methodologies. Finite element analysis must be augmented by multibody dynamics in comprehensive rotorcraft software in order to properly analyze large motions of rotorcraft components. A formulation for the large motion dynamic analysis of rotorcraft is presented, pointing out that, although this model may be used in an actual analysis, the multibody dynamics literature contains more efficient and flexible methodologies, the application of which are recommended as a priority goal for rotorcraft analysis.

L.K.S.

A90-46962#

AN IMPROVED ROTOR/AIRFRAME COUPLING METHOD FOR NASTRAN AIRFRAME VIBRATION ANALYSIS

EMAM HASHISH (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 13 p. refs

An elastic multidegree-of-freedom rotor model developed for use with finite element models of helicopter airframes and capable of being easily incorporated into a NASTRAN airframe model is described. The method, referred to as the direct impedance integration method, facilitates the production of accurate hub impedances at any frequency of interest. Other advantages of this method include its easy programmability which provides an alternative to the use of lumped mass rotor representation, improvement of helicopter airframe vibration analysis, and more accurate frequency tuning of the airframe with respect to rotor modes. The method is demonstrated using simple cantilever example and is validated by comparing calculated response transfer functions with vibration test results of a 0.2-scale semispan wind tunnel model. The component mode synthesis, which has the advantage of dealing with the rotor modes in the fixed coordinate

system explicitly, is cited as an alternative method. It is pointed out, however, that this method involves more lengthy development procedures and potential numerical errors while the impedance integration method avoids these errors. L.K.S.

A90-46964#

EXPERIENCES IN NASTRAN AIRFRAME VIBRATION PREDICTION AT BELL HELICOPTER TEXTRON

JAMES D. CRONKHITE and MICHAEL R. SMITH (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 16 p. refs

The use of NASTRAN analysis during the design process in order to achieve acceptable vibration levels with minimal design modifications during development flight test is described. The analysis involves tuning the pylon isolations system, and fuselage structure to minimize vibrations and position the important, hard-to-move modes away from rotor excitation frequencies. Some case histories during the development of the AH-1T, the Model 214ST, the Bell ACAP, and the V-22 are discussed. The NASA DAMBIVBS research program is examined, noting that it has provided an understanding of higher frequency vibration correlation, has identified modeling deficiencies to improve main-rotor 4p vibration predictions, and has recently contributed to the design of the V-22 three-bladed tilt rotor. L.K.S.

A90-46965#

APPLICATION OF THE WESTLAND CRFD PROGRAM TO TOTAL HELICOPTER DYNAMICS

P. T. W. JUGGINS (Westland Helicopters, Ltd., Yeovil, England) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 17 p. Research supported by the Ministry of Defence Procurement Executive. refs

The Westland CRFD (Coupled Rotor-Fuselage Dynamics) program is a module providing modal degrees of freedom within the Coupled Rotor-Fuselage Model, the development of which is the subject of collaborative research with the Royal Aerospace Establishment, UK, for the prediction of rotor loads and fuselage vibration in both level and maneuvering flight, as well as application to stability, performance and handling qualities. Applications of CRFD are described, to examples of total dynamic systems involving combinations of significant sub-systems with the main rotor. In particular, predicted natural frequencies and mode shapes of a rotor-fuselage model are presented, and compared with results from a more conventional approach which considers the rotor and fuselage separately. The form of the results is supported qualitatively by flight test measurements. Results suggest that effects of the rotor on fuselage modes and of hub motion on rotor modes are both significant. The contributions of other components, namely the transmission system, control system and blade lag dampers to the rotor dynamic characteristics are also assessed by application of CRFD and consideration of test measurements. Author

A90-46968#

APPLICATION TO A HELICOPTER OF A GENERAL METHOD FOR MODIFYING A FINITE-ELEMENT MODEL TO CORRELATE WITH MODAL TEST DATA

W. J. TWOMEY, T. L. C. CHEN (Sikorsky Aircraft, Stratford, CT), I. U. OJALVO, and T. TING (Bridgeport, University, CT) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 12 p. Research supported by Connecticut State Department of Higher Education and Sikorsky Aircraft. refs

(Contract DAAJ09-88-C-A003)

A newly developed computer program, PAREDYM, is described. The program is capable of calculating the optimum set of changes to be made to a finite element model (FEM) in order for its modal properties, frequency, and shape to correlate simultaneously with a set of target values. The program is written in MSC/NASTRAN

DMAP language and uses FORTRAN code for iterative control. The correlation method has been successfully applied as an aid in improving the FEM of a UH-60A helicopter so that it correlates with shake test data. The program isolated the problem areas in the model for closer analysis, which revealed that the addition of stiffness models to certain secondary structures, as well as the stiffening of the model of the main transmission, would result in significant modal improvements. It is noted that PARADYM can also be used as a design tool for removing undesirable modes from a critical frequency region for a new helicopter currently under way. L.K.S.

A90-46969#

V-22 MSC/NASTRAN AIRFRAME VIBRATION ANALYSIS AND CORRELATION

JOHN E. BRUNKEN, JR. (Bell Helicopter Textron, Inc., Fort Worth, TX) and ROBERT R. VLAMINCK (Boeing Helicopters, Philadelphia, PA) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 9 p. refs

The V-22 airframe structural design has been configured and tailored to achieve specific dynamic characteristics in order to minimize vibration and oscillatory loads and to provide good aeroelastic stability. An MSC/NASTRAN dynamics model has been developed and used as a design tool to achieve those characteristics. Ground vibration testing has been performed on both the ground test article (GTA) and the first flight aircraft, and flight testing has begun. This paper describes the tests and presents a comparison of test measurements with pretest predictions. Improvements made to the analytical model, based on the tests, are described, and a correlation of the improved model to test data is presented. Author

A90-46970#

DEVELOPMENTS IN GROUND VIBRATION TEST AND DATA ANALYSIS TECHNIQUES FOR AIRFRAME STRUCTURES

R. K. GOODMAN and P. C. VON HARDENBERG (Sikorsky Aircraft, Stratford, CT) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 14 p. refs

A review is given of recent developments in airframe ground vibration test and data analysis methods. Technological advancements in data acquisition and processing which have resulted in greatly improved data quality and quantity are discussed. Data analysis methods are shown to accurately identify complex (i.e. nonproportionally damped) modal parameters from frequency response data. Applications of modal models identified through the testing process are presented, including an example of the Structural Dynamic Modification method applied to UH-60A ground vibration data. Author

A90-46971*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

THE RESPONSE OF HELICOPTER ROTORS TO VIBRATORY AIRLOAD

WILLIAM G. BOUSMAN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 20 p. refs

The problems of oscillatory and vibratory loading are examined from the perspective of the rotor's structural response. Blade flap, chord, and torsion responses, from flight or wind tunnel tests of eight full-scale rotors are examined and compared for high-speed flight conditions in the absence of blade stall or maneuvers. Some important similarities and differences between rotors are considered, and it is pointed out that these observations are useful in determining the appropriate tests for development of theoretical prediction methods. Among other things, major similarities were found in the dominant flapping vibratory response which occurs at 3/rev, and the root oscillatory chord bending for the CH-34, the SA 349/2, and the UH-60A; differences noted include vibratory chord bending-moment behavior of the rotors, a difference in the

dampers-induced behavior of CH-53A root oscillatory chord bending, and unique torsion and pitch link loading behavior exhibited by the AH1-G articulated rotor. L.K.S.

A90-46972#

AN EXAMINATION OF HELICOPTER ROTOR LOAD CALCULATIONS

THOMAS H. MAIER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 20 p. refs

The calculation of flapwise bending moments from a known aeroelastic equilibrium solution is examined. CAMRAD, a comprehensive rotorcraft analysis, is used to obtain this equilibrium solution for three full-scale rotors including the CH-34, the SA349/2, and the BO-105, and the force-integration and curvature methods of calculating bending moments are demonstrated. The Blade Response to Aerodynamic Loading program (BRAL), a finite-difference method, was used to obtain accurate flapwise bending moments and was shown to agree well with strain-gage measurements on the CH-34 rotor in a wind tunnel. Results indicate that the CAMRAD/force-integration method accumulates error as the moment is integrated from tip to root, and that results from the CAMRAD/curvature method are contingent upon the radial station. CAMRAD shear forces showed no accumulation of error toward the blade root. When applied to the BRAL solution, the force integration solution gave reasonable bending-moment results. L.K.S.

A90-46974#

PREDICTION AND ALLEVIATION OF V-22 ROTOR DYNAMIC LOADS

DAVID A. POPELKA and ASHOK AGNIHOTRI (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 15 p. refs

The methodology used to develop the oscillatory rotor design loads for the V-22 is presented. Discussion of the design loads centers on three areas: rotor tuning, loads prediction methods, and loads alleviation techniques. The rotor design configuration and evolution of the frequency placement relative to the design constraints is described. The analytical methods and math model refinements developed to compute the oscillatory loads are discussed. Oscillatory loads are shown to be alleviated through the use of flight control laws that reduce the severity of the loading conditions without compromising the handling qualities or usable maneuvering capability. Author

A90-46975#

FREE WAKE ANALYSIS OF ROTOR CONFIGURATIONS FOR REDUCED VIBRATORY AIRLOADS

T. R. QUACKENBUSH, D. A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ), D. B. BLISS (Duke University, Durham, NC), and R. M. MCKILLIP (Princeton University, NJ) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 13 p. refs

The status of work in progress on an advanced free wake model for the prediction of helicopter rotor airloads in forward flight is summarized. Particular attention is given to the use of this model as an aid in the analysis and design of rotors that experience reduced vibratory airloads. Background on full-span free wake analysis is provided through documentation of curved vortex elements and a full-span wake model, two of the major elements used in wake simulations featured in the paper; lifting surface calculations for aerodynamic loads are also discussed, noting that a promising correlation of predictions exists for both low and high speed flight. Current blade dynamics and trim procedures are described, and free wake calculations and airload prediction rates to date are presented. Results to date indicate that the wake model presented, when coupled with a lifting surface

model of the blade aerodynamics, has considerable promise as a tool in the prediction of unsteady airloads. L.K.S.

A90-47306*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ACTIVE CONTROL OF PROPELLER-INDUCED NOISE FIELDS INSIDE A FLEXIBLE CYLINDER

HAROLD C. LESTER (NASA, Langley Research Center, Hampton, VA) and CHRIS R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1374-1380. Previously cited in issue 12, p. 3223, Accession no. A86-45442. refs
Copyright

A90-47738#

OPTIMAL PERIODIC CRUISE WITH SINGULAR CONTROL

GOTTFRIED SACHS and KLAUS LESCH (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1586-1594. refs

(AIAA PAPER 90-3490) Copyright

Aircraft cruise for maximizing range per fuel is considered as an optimal periodic control problem. Both mathematics and flight-mechanics aspects concerning the existence of singular arcs in optimal periodic cruise of aircraft are covered. Optimality conditions for periodic aircraft cruise are considered, with emphasis on singular control conditions. Numerical results are presented for optimal trajectories as well as an evaluation of the achievable reductions in fuel consumption. Based on the equivalence between singular and chattering control, it is shown that chattering arcs exist for a more realistic fuel-consumption model. For this model, reductions in fuel consumption achievable with optimal periodic cruise are significantly larger than for the idealized model. Author

A90-48522

FLYING THE GIANT

Flight International (ISSN 0015-3710), vol. 138, Aug. 22, 1990, p. 36-40.

Copyright

A Western pilot has flown and evaluated the 392-ton An-124 Ruslan, a cargo transport incorporating a range of equipment for loading, stowing and keeping freight. With six crewmembers in addition to the two pilots, the latter are relieved of all functions except VHF communications and flying the aircraft. Four three-spool Lotarev D-18T turbofans having 15 compressor stages, an annular combustion chamber, and six turbine stages, power the Ruslan. Flight controls are operated by four hydraulic systems. In flight, cruise regime is set by N1 as opposed to the use of EPR for takeoff. With two engines out, climb is possible at weights up to 330 tons and missed procedure may be executed at 300 tons down to 100 meters. R.E.P.

A90-48699

CERTIFICATING THE SPEED CANARD

IAN PARKER Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, Sept.-Oct. 1990, p. 36, 37, 39.

Copyright

An account is given of the unique considerations deemed essential by the FAA during the certification process for the German all-composite airframe Speed Canard, which is the first aircraft of this type intended for a large production run. While the aircraft is primarily of GFRP, carbon and aramid fiber reinforcement are respectively used on the compression and tension sides of the landing gear legs. Ultimate strength has been designed to exceed that of a comparable metallic structure by a margin of 15 percent; certification has demonstrated that neither manufacturing faults nor impact damage can propagate catastrophically without producing visible damage that would be immediately apparent to inspectors. Destructive tests were conducted on the canard structures. O.C.

A90-48831#

THICK-WING SPANLOADER ALL-FREIGHTER - A DESIGN CONCEPT FOR TOMORROW'S AIR CARGO

FABIO R. GOLDSCHMIED (Engineering and Research-Aerodynamics/Hydrodynamic Systems, Monroeville, PA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs (AIAA PAPER 90-3198) Copyright

A conceptual design is formulated for a 300,000-lb gross weight class spanloader freighter configuration whose rectangular-planform wing carries 150,000 lbs of cargo at 300 mph, over a nonstop range 2500 miles. This highly innovative system integrates such existing aircraft systems developments as the 'GLAS II' 31.5-percent thick airfoil, slot-suction boundary-layer control, and a double-inlet/double-width centrifugal blower devised by Goldschmied in 1968. Projected spanloader performance levels are put in perspective in view of the established capabilities of the C-130H cargo aircraft; where this conventional turboprop has a maximum transport efficiency value of 10, the present spanloader reaches a value of 25. O.C.

A90-48832#

THE HILLER X-18 EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

J. B. NICHOLS (Boeing Aerospace and Electronics, Dayton, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 20 p. refs (AIAA PAPER 90-3203) Copyright

The history leading up to the X-18 program and the development program itself is reviewed. An attempt is made to reconstruct the basis for each of the decisions made and the consequences of these decisions as disclosed by the problems avoided, solved, or generated. As many key members of the original development team as possible were interviewed to recall and corroborate the facts. Conclusions are drawn which, hopefully, will serve as 'Lessons Learned' to a new generation of VTOL programs.

Author

A90-48833#

THE CANADAIR CL-84 EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

FREDERICK C. PHILLIPS AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 14 p. refs (AIAA PAPER 90-3205) Copyright

After seven years of V/STOL studies by Canadair, design of the CL-84 tilt-wing prototype began in 1963. Three articles were developed and flown between 1965 and 1974 for 476 hours total, including important operations at USNATC and at sea. Prime emphasis on flying qualities and the changes triggered by pilot comments were primarily responsible for positive reactions by almost all 40 pilots who flew the CL-84. During the program many technical and organizational/managerial lessons were learned, of significance particularly to Canadair, which had previously designed and built in-house only a jet-trainer airplane. Lack of success in a military market dominated by jet and helicopter advocates caused Canadair to abandon tilt-wing activities in favor of more conventional pursuits. While the tilt-wing scores well technically for certain missions, the current overall situation, at least in North America, does not augur well for its future, especially if V-22 tilt-rotor production ensues.

Author

A90-48834#

THE CURTISS-WRIGHT X-19 EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

HENRY V. BORST (Henry Borst Associates, Dayton, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. refs (AIAA PAPER 90-3206) Copyright

The paper reviews the X-19 tandem wing tilt propeller VTOL aircraft experimental program. The technical aspects of the design are discussed along with reasons for the use of the radial lift

propellers. The experimental program and results are given along with the lessons learned.

Author

A90-48835#

THE BELL X-22A V/STOL, VARIABLE STABILITY RESEARCH AIRPLANE - LESSONS LEARNED

JOHN L. BEILMAN AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 19 p. refs (AIAA PAPER 90-3207) Copyright

The concept, design, development, and flight testing of the X-22A experimental aircraft are reviewed. Aerodynamic features of particular interest were the high forces and moments available for control with four tilting, ducted propellers arranged in tandem pairs. This configuration also featured a multi-axes variable stability and control system, sensing all of the rigid body motions and relative wind variables, making it possible to alter most of the stability and control derivatives through aircraft response feedback techniques. Solutions to the problems encountered as well as performance goals and achievements are discussed. Finally, a review of lessons learned from this experimental V/STOL research aircraft is presented.

R.E.P.

A90-48841#

CONCEPTUAL DESIGN AND FEASIBILITY STUDY OF VERY LARGE PASSENGER AIRCRAFT

P. M. SAGDEO (Western Michigan University, Kalamazoo, MI) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 9 p. refs (AIAA PAPER 90-3220) Copyright

The paper presents designs of two very large capacity passenger transports. These aircraft are seen as the solution to the problem of air traffic congestion at major airports around the world. These aircraft will potentially reduce the number of flights of heavy aircraft to as few as 25 percent of the current flights. Two designs are presented: one for a 1000-passenger, 5000-mile range aircraft and another for a 2000-passenger, 6000-mile range aircraft. Both are based on the conventional aft-tail design to emphasize simplicity of design and construction and utilize only the projected development in the aerodynamics, propulsion, control and materials technology to reduce the risk factors involved. A very simple cost analysis shows that these aircraft are viable at appropriate load factors.

Author

A90-48844#

PRELIMINARY DESIGN OF A SUPERSONIC SHORT TAKEOFF AND VERTICAL LANDING (STOVL) FIGHTER AIRCRAFT

BRIAN COX and JAN ROSKAM (Kansas, University, Lawrence) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. Research sponsored by the Universities Space Research Association. refs (AIAA PAPER 90-3231) Copyright

A preliminary design study of a supersonic short takeoff and vertical landing fighter is presented. Three configurations (a lift + lift/cruise concept, a hybrid fan vectored-thrust concept, and a mixed-flow vectored-thrust concept) were initially investigated with one configuration selected for further design analysis. The selected configuration (the lift + lift/cruise concept) was successfully integrated to accommodate the powered lift short takeoff and vertical landing requirements as well as the demanding supersonic cruise and point performance requirements. A supersonic fighter aircraft with a short takeoff and vertical landing capability using the lift + lift/cruise engine concept seems a viable option for the next-generation fighter.

Author

A90-48846#

RYAN X-13 EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

WILLIAM T. IMMENSCHUH (San Diego Aerospace Museum, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. (AIAA PAPER 90-3236) Copyright

The Ryan X-13 VATOL (Vertical Attitude Take-off and Landing) aircraft was a classical Experimental and Development Program

and proceeded from a concept to hardware and to a flight demonstration in an orderly sequence. The X-13 demonstrated, very successfully, a pure turbo-jet powered aircraft capable of sustained hovering flight followed by transition to horizontal forward flight and return to vertical attitude flight and landing. The program utilized advancements in turbo-jet engine development and availability in the 1950 time period. The concept employed a take-off and landing device at a predetermined location with limited provisions for emergency landings. As it turned out, no military missions emerged for this concept, although, the potential still exists today. The aircraft, designed with a closed loop stabilization system, and jet reaction control demonstrated excellent controllability in the vertical attitude mode and comfortable transitions to and from horizontal high speed flight. Pilot position in the vertical attitude was acceptable but was not fully optimized for an operational configuration. Originally a U.S. Navy project, the U.S. Air Force took over the program with the designation X-13. This report describes the various phases of the development and flight demonstration and the Lessons Learned. Author

A90-48847#

THE AVRO VZ-9 EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

DANIEL C. MURRAY (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 7 p. refs

(AIAA PAPER 90-3237) Copyright

This paper discusses the development, manufacture and ground and flight test of the AVROCAR (VZ-9AV) aircraft. It covers, in the test phases, several short-comings in the overall design objectives, briefly discusses flight test results and concludes with 'lessons learned' and recommendations. Author

A90-48848#

THE HAWKER P1127 VECTORED THRUST FIGHTER PROGRAM - LESSONS LEARNED

JOHN W. FOZARD AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 15 p.

(AIAA PAPER 90-3238) Copyright

The P1127 program of 1957-63 leading to the Kestrel (XV-6A) and the Harrier (AV-8A) aircraft of the mid-and late 1960s provided a benchmark for successful and economic development in the jet V/STOL field. Descriptions are given of early powered lift flight problems and progress, and the struggle to overcome deficiencies of the configuration in fully wingborne flight. The parallel development of the Pegasus engine with that of the aircraft and its V/STOL systems are emphasized, and overall success shown to derive from the closest collaboration between the engine and airplane design teams. The P1127's development process of incremental advance is shown to have been a key feature of the entire program which pointed the way to the Kestrel of 1964-68 - the world's first jet V/STOL airplane to be certified for service use - and hence to the Harrier of 1966-70, the world's first truly operational jet V/STOL attack fighter. An outline is given of the engineering and management methods used and the major lessons learned are set out so as to illuminate the best pathways toward success in future jet V/STOL programs. Author

A90-48849#

DESIGN OF A CLOSE-SUPPORT AIRCRAFT

RAY WHITFORD (Royal Military College of Science, Shrivenham, England) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs

(AIAA PAPER 90-3241) Copyright

This paper discusses the feasibility study of a Close-Support aircraft carried out by Royal Air Force Engineering Officers at the Royal Military College of Science, Shrivenham - a faculty of Cranfield Institute of Technology. The design requirement for the aircraft, a replacement for the Fairchild A-10 Thunderbolt, is stated at length. The artificial design restraints imposed for educational

and resource reasons are mentioned. Only a limited amount of the total design effort is reviewed. Topics included are: Armament and Stores Carriage, Avionics, Crew Number Selection and Cockpit Layout, Powerplant Selection, Configuration Evolution, Aerodynamic Design, Stability and Control, Weight Breakdown and Aircraft Performance. Comparisons with other contemporary aircraft are given. Author

A90-48852#

RIDE QUALITY CRITERIA FOR THE B-2 BOMBER

STEVEN B. JACOBSON and JOHN F. MOYNES (Northrop Corp., Pico Rivera, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 6 p. refs

(AIAA PAPER 90-3256) Copyright

Ride quality analysis is an integral part of the design and development of current and future low flying military aircraft. Ride quality analysis is used to predict the pilot and crew's ability to withstand turbulence induced whole body vibrations, and their ability to perform the necessary mission tasks (i.e. fly the airplane) in this environment. An air vehicle which is designed to function in an adverse turbulent environment must not only withstand the physical loads on the structure, but also provide an adequately smooth ride for it's crew to perform. Accurately predicting and meeting these design requirements is necessary so that the crew may function properly and achieve the overall mission design goals of the air vehicle. This paper presents the ride quality analysis criteria used to predict the ride quality for the USAF B-2 bomber. Author

A90-48857#

ANALYTIC MODELS FOR TECHNOLOGY INTEGRATION IN AIRCRAFT DESIGN

W. H. MASON (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. refs

(AIAA PAPER 90-3262) Copyright

Simple algebraic models of the aerodynamics, structures and propulsion technologies that control the size and shape of aircraft are used to illustrate the importance of considering the technologies simultaneously when developing new configurations. The models illustrate simply the best use of advances in each technology. The proper integration of advanced technologies is not necessarily intuitive. Case studies are given for the range dominated transonic transport and the maneuver dominated fighter. The results provide a direct means of understanding the technology integration issues and interpreting results from large aircraft sizing programs. Author

A90-48859#

THE BELL HELICOPTER XV-3 AND XV-15 EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

T. H. THOMASON (Bell Helicopter Textron, Inc., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p.

(AIAA PAPER 90-3265) Copyright

Bell Helicopter Textron was the prime contractor for both the XV-3 and the XV-15 TiltRotor Aircraft Programs. Although both were 'successful', in that an extensive evaluation of the capability of both aircraft was accomplished, the XV-15 Program achieved far more of the goals established for it, primarily due to the lessons learned about the concept as a result of the XV-3 Program. Author

A90-48860#

THE MH-60K - A SPECIAL ROTORCRAFT FOR SPECIAL OPERATIONS

JOHN SINNOTT and JOHN SCHNEIDER (Sikorsky Aircraft, Stratford, CT) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 6 p.

(AIAA PAPER 90-3266)

This paper describes the Army/Sikorsky MH-60K Special

Operations Aircraft (SOA), a BLACK HAWK derivative providing the airlift capability needed to conduct Special Operations Forces (SOF) missions. The paper first reviews system design and program requirements for the MH-60K air vehicle and its avionics subsystem. Necessary configuration changes to the parent BLACK HAWK aircraft are identified and the performance of the resultant MH-60K is presented. Finally, the current program status for development, production, and in-service support is discussed. Author

A90-48861#

APPLICATION OF ADVANCED AIR VEHICLE AND MISSION EQUIPMENT TECHNOLOGIES TO THE LIGHT HELICOPTER (LH)

ROBERT HUBBARD and DARREL CALDWELL (U.S. Army, Light Helicopter Program Management Office, Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. (AIAA PAPER 90-3268)

This paper will discuss how the US Army is applying advanced air vehicle and mission equipment technologies to the Light Helicopter (LH) to achieve increased mission effectiveness and survivability. Within the length of this paper and due to several competition sensitive issues, it is impractical to discuss all of the significant technology improvements under consideration by both LH Contractor Teams. Therefore, this paper will discuss several of the most critical air vehicle and mission equipment technologies that both LH Contractor Teams are applying to the LH as well as the top level design requirements for the Light Helicopter. Author

A90-48862#

THE BELL HELICOPTER AH-1 COBRA - PAST, PRESENT, AND FUTURE

ROBERT R. LYNN and JAMES H. HARSE (Bell Helicopter Textron, Inc., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 9 p.

(AIAA PAPER 90-3271) Copyright

The evolution of the AH-1 Cobra from its inception more than 25 years ago is presented. During those years many variants and system upgrades have been developed as new technologies and increased mission requirements evolved. Continuing developments are taking place for advanced models that include rotor and drive system upgrades that will increase the survivability, reliability, maintainability, maneuverability, performance, and mission effectiveness. Advanced systems including night targeting and navigational improvements are also being developed. R.E.P.

A90-48863#

A THEORETICAL AND EXPERIMENTAL INVESTIGATION INTO THE PREROTATION OF AIRCRAFT TIRES

IAN SOBIESKI (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 15 p. refs

(AIAA PAPER 90-3272) Copyright

This paper investigates the feasibility of using the freestream air flow around the lowered landing gear of an aircraft to aerodynamically rotate that aircraft's tires prior to landing; thus reducing wear on the tires. Wind tunnel experiments were performed on a model wheel and the results scaled to predict shuttle wheel performance. The experimentation and analysis showed that aerodynamic inducement of rotation prior to landing is a feasible option for the space shuttle and may result in a 50-percent reduction of tire wear. Such a reduction would enable the shuttle to resume landings at the Kennedy Space Center. Various references indicate that the prerotation devices might find useful application in commercial aviation through the reduction of landing gear strut dynamic loads, runway pollution, and tire wear. Finally, these devices could have a role in alleviating the tire wear problems expected to occur on the National Aerospace Plane. Author

A90-48865#

SUBSYSTEM THERMAL INTEGRATION - A NEW CHALLENGE TO THE AIRCRAFT DESIGNER

RALPH L. HERRING (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 8 p. refs (AIAA PAPER 90-3274) Copyright

An engineering design function having one of the highest potentials for significant improvement in aircraft equipment reliability, availability, supportability, and sustainability is dedicated thermal design and integration. All aircraft subsystems have temperature critical components or elements which directly influence failure rate. Improvements in the temperature control of these critical items can provide desirable reductions of overall weapon system life cycle cost. A key element of this thrust to achieve improved aircraft quality is the amount of attention given to total subsystem thermal integration. Better control of component temperature levels and near optimum use of available heat sinks will be key aircraft design parameters. Knowing what is required, why it is required, how to perform the desired functions, who needs to perform the functions, and making sure these functions are performed when needed are all necessary steps leading to the desired aircraft quality. Complete subsystem thermal integration at all levels of aircraft development is needed to provide true quality gains. Author

A90-48866#

CONDOR - HIGH ALTITUDE LONG ENDURANCE (HALE) AUTONOMOUSLY PILOTED VEHICLE (APV)

ROBERT JOHNSTONE (DARPA, Arlington, VA) and NEIL J. ARNTZ (Boeing Military Airplanes, Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p. (AIAA PAPER 90-3279)

Condor is an experimental Autonomously Piloted Vehicle (APV) that has successfully flown eight times. This large, high altitude long endurance (HALE) air vehicle achieved two world records, one for an altitude of 66,980 feet (barometric reading) and one for endurance of 58 hours, 11 minutes. Unlike other unmanned or remotely piloted air vehicles, Condor flies autonomously from takeoff through landing. Prior to takeoff a preprogrammed mission (updatable in flight if desired) is stored in onboard computers. Condor provides a large volume suitable for a wide range of reconnaissance, surveillance of other mission payloads. It is the result of the successful application and integration of four state-of-the-art technologies: aerodynamics, propulsion, composite structures and autonomous control. The technology integration is discussed in detail in this paper along with a summary of the flight test results, a look ahead at possible operational configuration enhancements, and a review of potential applications for Condor. Author

A90-48869#

ALL FABRIC N-WING UNMANNED POWERED FLIGHT SYSTEMS

JOHN D. NICOLAIDES (Aero Corp., San Luis Obispo, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. refs (AIAA PAPER 90-3282) Copyright

The Nicolaides Flyer, an unmanned air vehicle (UAV) parafoil system, is described. Hypersonic wind tunnel tests, subsonic flight tests, and flight data analyses are reviewed with particular attention given to experimental demonstrations and theoretical flight predictions. These tests are directed at high-low speed stealth systems and high-low altitude, direct fly-up into space systems, and space recovery systems. The parafoil UAV is constructed completely of fabric and is capable of gliding like any unpowered aircraft. With a deployment altitude of over 60,000 ft and L/D equal to 8 plus, a range of 100 miles may be achieved with landing accuracies of + or - 1 ft. Hypersonic wind tunnel tests have shown the possibilities of deployment in space and flights directly back to earth and also flights from the ground into space. R.E.P.

A90-48876#

SYSTEM OPTIMIZATION FOR MAXIMIZING RECONNAISSANCE MISSION RANGE OF A HYPERSONIC CRUISE VEHICLE

H. G. KAUFFMAN, R. V. GRANDHI, W. L. HANKEY, and P. J. BELCHER (Wright State University, Dayton, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p. refs
(Contract F33615-87-C-1550)

(AIAA PAPER 90-3292) Copyright

Recent technological advances in fields related to hypersonic aircraft development, such as high temperature materials, light weight structures and high thrust to weight ratio engines indicate that a strategic vehicle at higher Mach numbers (approx. 6) is feasible. An efficient performance analysis method is developed to evaluate potential hydrogen fueled turbojet and ramjet propulsion systems for advanced technology hypersonic cruise vehicles. A conceptual strategic reconnaissance mission is evaluated for tradeoffs between throttle and angle of attack control in minimizing fuel consumption/maximizing range. Many mission, flight, and vehicle related requirements and constraints are satisfied in the design process. In addition, powered hypersonic flight produces unique performance characteristics not encountered at subsonic speeds.

Author

A90-48877*# Analytical Sciences Corp., Research Triangle Park, NC.

COMPARISON OF EQUIVALENT PLATE AND FINITE ELEMENT ANALYSIS OF A REALISTIC AIRCRAFT STRUCTURAL CONFIGURATION

PI-JEN KAO (Analytical Services and Materials, Inc., Hampton, VA), GREGORY A. WRENN (Lockheed Engineering and Sciences Co., Hampton, VA), and GARY L. GILES (NASA Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 8 p. refs

(AIAA PAPER 90-3293) Copyright

This paper presents a comparison study to assess how well a realistic aircraft structure can be represented with an equivalent plate model. A wing box and full wing structure of a high-speed civil transport aircraft configuration are analyzed. Static and vibration results from the equivalent plate analysis are compared with results from a finite element model. The results from these comparisons show that, for the simpler wing box models, the static displacements and first vibration frequency agree to within 1.5 percent. The full wing models only agree to within 10 percent, for both models, the higher frequencies vary by as much as 26 percent. These differences are due to inadequate refinement of the equivalent plate model.

Author

A90-48879#

THE BAE (COMMERCIAL AIRCRAFT) LTD TRANSPORT AIRCRAFT SYNTHESIS AND OPTIMISATION PROGRAM (TASOP)

J. M. COUSIN and M. P. METCALFE (British Aerospace /Commercial Aircraft/, Ltd., Stockport, England) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 9 p.

(AIAA PAPER 90-3295) Copyright

This paper describes the philosophy and methods used in solving the problems and realizing the full potential of utilizing optimization techniques at the initial aircraft design stage. The approach taken to the solution of this problem was to structure existing design methods in a computer program and apply state of the art numerical optimization techniques. The development of the model, in order to utilize new design methods, is an ongoing program. A transport aircraft synthesis model was developed whose structure is suitable for preliminary design optimization. The paper presents concise results of several studies performed, and illustrates the potential uses of the design optimization approach in preliminary design studies.

Author

A90-48880#

ADVANCED ROTORCRAFT V/STOL - TECHNOLOGY NEEDS FOR HIGH-SPEED ROTORCRAFT

JOHN SCHNEIDER and JOSEPH WILKERSON (Boeing Helicopters, Philadelphia, PA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p.

(AIAA PAPER 90-3298) Copyright

This paper reports on Boeing's effort in the NASA-contracted study of 'Technology Needs for High-Speed Rotorcraft'. Initially, 20 concepts were defined for a comparative evaluation. The five most attractive concepts were selected for mission analysis and more detailed conceptual definition. This provided the data for assessment and recommendation of two concepts for the technical evaluation, advanced technology assessment, and development of an enabling technology plan.

Author

A90-48884#

MULTI-ROLE ADVANCE TECHNOLOGY ROTORCRAFT - THE EH101

JOHN W. LEVERTON (E. H. Industries, Inc., Arlington, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p.

(AIAA PAPER 90-3302) Copyright

The paper outlines in general terms the multi-role EH101 Advanced Technology Rotorcraft designed to meet the needs of the navy, military and civil operator in the mid-1990s and beyond. The basic design parameters of the three variants, including the rear ramp unit available on the military/utility and civil variants, are outlined together with the general performance characteristics. Reference is made to the 'fixed-wing' design philosophy adopted, the glass cockpit, HUM system and active vibration control units incorporated in the EH101. Some of the development issues are also discussed.

Author

A90-48885#

X-29 HIGH ANGLE-OF-ATTACK FLIGHT TESTING - PROGRAM STATUS

G. W. HUBAND and W. J. GILLARD (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p. refs

(AIAA PAPER 90-3303)

The X-29 is a forward swept wing aircraft, about the size of an F-5, which incorporates several important technologies relevant to high angle-of-attack flight. These include forward swept wings, close coupled canards, three surface pitch control, and digital fly-by-wire flight control system. The high angle-of-attack flight test of the X-29-2 has nearly completed the aircraft envelope expansion up to 0.6 Mach between 25,000 and 40,000 feet of altitude. In angle-of-attack, this included 1-g pitch up maneuvers to 66 deg and three axes maneuvering to 40 deg, with a normal load factor of 3.5-g attained during a wind up turn at 35 deg angle-of-attack. The high angle-of-attack flight control system performed well, showing that a statically unstable aircraft could be controlled at very high angles-of-attack.

Author

A90-48886#

CONFIGURING TACTICAL AIRCRAFT

STEVEN J. D'URSO (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. refs

(AIAA PAPER 90-3305) Copyright

This paper discusses the importance of requirements and how they drive the configuration process. The process of determination of tactical aircraft requirements and evaluation is delineated. The configuring of an aircraft to those requirements, performance evaluation and optimizing procedures are described. Several examples are presented of how requirements such as supersonic performance, specific mission profiles, short or vertical takeoff and landing, carrier suitability, or aircraft supportability requirements can drive configurations and impact concept development.

Author

A90-48887#

STATUS OF THE STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR FLIGHT TEST PROGRAM

DAVID J. MOORHOUSE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 8 p.
(AIAA PAPER 90-3306)

The STOL and Maneuver Technology Demonstrator (S/MTD) Program was formulated to demonstrate technologies enabling a supersonic flighter to have STOL capabilities and enhanced combat performance. Following contract award in October 1984, many thousands of hours of ground testing were performed to develop and clear the flight configuration. Flight testing began in September 1988, and is proceeding through various stages to accomplish the program goals. The objective of this paper is to define the S/MTD program goals, summarize the configuration development and discuss the flight test accomplishments to date. Author

A90-48951

COAXIAL HELICOPTERS - CURRENT STATUS AND FUTURE DEVELOPMENTS

VENIAMIN A. KAS'IANIKOV (Kamov Design Bureau, Moscow, USSR) Vertiflite (ISSN 0042-4455), vol. 36, Sept.-Oct. 1990, p. 46-54.

Copyright

Historically, coaxial rotor helicopters found their initial applications in the USSR where such characteristics as compactness and aerodynamic symmetry were most important; these features are at a premium aboard aircraft carriers and other helicopter-employing naval vessels. Additional virtues of coaxial-rotor helicopters are hovering efficiencies 17-30 percent greater than those of comparable single-rotor configurations, aerodynamic symmetry, and large deflections of lateral and longitudinal control forces. Attention is presently given to the development history of the Kamov Ka-27 and Ka-32 helicopters and their civilian variants. O.C.

A90-48952

HELICOPTER OR TILTROTOR - A SOVIET VIEW

MARAT N. TISHCHENKO (Vertoletnyi Zavod, Moscow, USSR) Vertiflite (ISSN 0042-4455), vol. 36, Sept.-Oct. 1990, p. 55-59.

Copyright

Tilt-rotor VTOL aircraft, known as 'vintoplanes' in the USSR, are presently evaluated from a Soviet perspective. A consideration of weight efficiency values realistically obtainable with current technologies shows that takeoff weights for tiltrotors are 1.4-1.5 times greater than those of comparable helicopters, leading to unit and operational costs which are also proportionately higher. It is therefore reasonable to direct tilt-rotor development efforts toward design solutions yielding improved weight efficiencies. Attention is given to more conventional helicopter configurations currently under consideration by the USSR's Mil design bureau. O.C.

A90-48955#

METHOD FOR SIMULTANEOUS WING AERODYNAMIC AND STRUCTURAL LOAD PREDICTION

MARK DRELA (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 692-699. Research supported by MIT. Previously cited in issue 21, p. 3263, Accession no. A89-47659. refs

Copyright

A90-48958*# Boeing Commercial Airplane Co., Seattle, WA.

TRANAIR APPLICATIONS TO ENGINE/AIRFRAME INTEGRATION

A. W. CHEN, M. M. CURTIN, R. B. CARLSON, and E. N. TINOCO (Boeing Commercial Airplanes, Seattle, WA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 716-721. Previously cited in issue 21, p. 3263, Accession no. A89-47632. refs
(Contract NAS2-12513)

Copyright

A90-49102*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DESIGN SYNTHESIS AND OPTIMIZATION OF JOINED-WING TRANSPORTS

JOHN W. GALLMAN, STEPHEN C. SMITH (NASA, Ames Research Center, Moffett Field, CA), and ILAN M. KROO (Stanford University, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. refs

(AIAA PAPER 90-3197)

A computer program for aircraft synthesis using a numerical optimizer was developed to study the application of the joined-wing configuration to transport aircraft. The structural design algorithm included the effects of secondary bending moments to investigate the possibility of tail buckling and to design joined wings resistant to buckling. The structural weight computed using this method was combined with a statistically-based method to obtain realistic estimates of total lifting surface weight and aircraft empty weight. A variety of 'optimum' joined-wing and conventional aircraft designs were compared on the basis of direct operating cost, gross weight, and cruise drag. The most promising joined-wing designs were found to have a joint location at about 70 percent of the wing semispan. The optimum joined-wing transport is shown to save 1.7 percent in direct operating cost and 11 percent in drag for a 2000 nautical mile transport mission. Author

A90-49104#

THE LTV XC-142 EXPERIMENTAL AIRCRAFT LESSONS LEARNED

GEORGE E. DAUSMAN (U.S. Army, Washington, DC) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 20 p. refs
(AIAA PAPER 90-3204)

The Tri-Service XC-142 tilt-wing V/STOL aircraft program is discussed, and program objectives, execution, aircraft description, milestones, accomplishments, and funding history are covered. Emphasis is placed on lessons learned during the program. It is noted that the program achieved its primary objective of evaluating operational suitability, that the aircraft met its VTOL performance and operational requirements. Shortfalls in reliability, performance, and effectiveness are identified, and they are deemed to be correctable through complete development testing, qualification, and application of current advanced technologies. V.T.

A90-49105#

X-WING EXPERIMENTAL AIRCRAFT - LESSONS LEARNED

NORRIS J. KRONE, JR. (Maryland, University Research Foundation, Greenbelt) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 23 p. refs
(AIAA PAPER 90-3208)

The concept and programs pursued to develop the X-wing experimental aircraft, which employs a four-bladed, rigid rotor that can be stopped in flight and flown as a fixed wing aircraft, are described in detail. It is pointed out that the X-wing concept promises to develop an aircraft that can operate in both the vertical and horizontal flight modes with potential cruise speeds in excess of 400 knots. The circumstances that caused the final termination of the development activity are discerned and a number of lessons learned from the X-wing experience are highlighted, including the need to identify the potential technical problems and uncertainties and to focus resources on solving them prior to development, the need to remain clear of man-rated requirements until basic design technologies are well understood, and the need to establish realistic and complete objectives and a level of acceptable risk before formulating the program and establishing program costs. L.K.S.

A90-49108#

UNIQUE FEATURES AND INNOVATIVE APPLICATION OF ADVANCED COMPOSITES TO THE MD-11

M. ASHIZAWA (Douglas Aircraft Co., Long Beach, CA) and Y. TOI (Fuji Heavy Industries, Ltd., Utsunomiya, Japan) AIAA, AHS,

and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs
(AIAA PAPER 90-3217) Copyright

Advanced composites fulfill the need to save weight which is essential in meeting the high-performance requirements of modern transport. The MD-11 uses more than 9,000 pounds of composites. The successful DC-10 composite flight service evaluation test program initiated in 1976 has shown that composites are durable and require minimum maintenance. Further, the program has given us the necessary confidence to use a great quantity of composites on the MD-11. A new design philosophy has been incorporated in the MD-11 which puts greater emphasis on reliability, maintainability, durability and producibility, even though this may result in some weight penalty. Several representative structural components are depicted to show the unique design features resulting from the new design philosophy. Design, fabrication, and analysis of the MD-11 outboard aileron are described in detail to demonstrate how the new design philosophy and unique features have been incorporated into the structure at various stages of development. Damage assessment, repair philosophy, and repair methods are also discussed. Customer airline requirements and complaints on repair of composites have helped in establishing improved inspection and repair criteria. Author

A90-49109#

TAGUCHI METHODS IN CONCEPTUAL DESIGN FOR LIFE CYCLE COST

S. A. INGALLS, C. L. MARTIN, W. MAYVILLE, J. E. ROGAN, and M. SHUBERT (Georgia Institute of Technology, Atlanta) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 8 p. refs
(AIAA PAPER 90-3222) Copyright

Parametric life cycle cost (LCC) models may be utilized in conceptual design to calculate LCC as a basis for comparison of diverse configuration, production, and support concepts. Cases from conceptual design sizing are employed to explain the basic concepts in Taguchi methodologies. Taguchi methods are used in two conceptual design studies to evaluate the effect of conceptual design choices on the expected value and variability in LCC. It is concluded that the curve-fitting approach to life cycle cost estimation wastes valuable data concerning the relationship between design options and the variability in LCC. Jaynes maximum entropy principle and Bayes theorem are proposed as alternative techniques. While Taguchi's methodologies and philosophy seem to be a useful tool for bringing downstream LCC into early conceptual design, a more sophisticated approach to the utilization of statistical procedures in aircraft design is required to achieve these benefits. R.E.P.

A90-49112#

PROPULSION SYSTEM DESIGN SPECIFICATIONS BASED ON STOVL FLIGHT CONTROL REQUIREMENTS

ABBAS EMAMI NAEINI, NASSER M. KHRAISHI, JAMES H. VINCENT (Systems Control Technology, Inc., Palo Alto, CA), and DONALD F. BERG (GE Aircraft Engines, Cincinnati, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. refs
(AIAA PAPER 90-3227) Copyright

The propulsion subsystem specification generation technique is a mechanism for defining how subsystems within an integrated control system should perform in order to accomplish the performance goals of the overall system. This design methodology makes it possible for experts on each subsystem to address individual design problems without sacrificing the overall performance of the integrated system. In this paper, an overview of this design technique will be given; details of applying the subsystem specifications generation technique to the short take-off and vertical landing control system design problem will be presented. Finally, lessons learned from applying this technique to the above problem will be discussed. Author

A90-49114*# General Dynamics/Fort Worth, TX.

THE IMPLEMENTATION OF STOVL TASK-TAILORED CONTROL MODES IN A FIGHTER COCKPIT

DAVID W. WHATLEY, JOHN C. VIRNIG, and DAVID S. BODDEN (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 9 p. refs
(Contract NAS3-25193)
(AIAA PAPER 90-3229) Copyright

The implementation of Short Takeoff/Vertical Landing (STOVL) specific task tailored control modes in a supersonic fighter/attack aircraft cockpit is investigated. A detailed linear model exhibiting STOVL Level 1 handling qualities is implemented in a real time engineering workstation environment with an F-16 cockpit mock-up. Conventional F-16 control inceptors are utilized to achieve effective STOVL operation and reduced pilot workload throughout the transition to hover flight region. Favorable pilot comments indicate the existing F-16 cockpit configuration with a force sidestick is adaptable to STOVL operation. Author

A90-49115#

A HYPERSONIC RESEARCH VEHICLE TO DEVELOP SCRAMJET ENGINES

G. M. GREGOREK and R. L. REUSS (Ohio State University, Columbus) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. refs
(AIAA PAPER 90-3232) Copyright

Four student design teams produced conceptual designs for a research vehicle to develop the supersonic combustion ramjet (scramjet) engines necessary for efficient hypersonic flight. This research aircraft would provide flight test data for prototype scramjets that is not available in groundbased test facilities. The design specifications call for a research aircraft to be launched from a carrier aircraft at 40,000 ft and a Mach number of 0.8. The aircraft must accelerate to Mach 6 while climbing to a 100,000 foot altitude and then ignite the experimental scramjet engines for acceleration to Mach 10. The research vehicle must then be recovered for another flight. The students responded with four different designs, two piloted waverider configurations, and two unmanned vehicles, one with a blended wing-body configuration, the other a delta wing shape. All aircraft made use of an engine database provided by the General Electric Aircraft Engine Group; both turbofanramjet and scramjet engine performance using liquid hydrogen fuel was available. This paper describes the students' conceptual designs, and the aerodynamic and propulsion concepts that made their designs feasible. The paper also touches upon interesting problems that surfaced during the design process. Author

A90-49118#

THE NORTH AMERICAN ROCKWELL XFV-12A - REFLECTIONS AND SOME LESSONS

RONALD D. MURPHY (DARPA, Arlington, VA), IRIS E. WILKEN (DGI Engineering Technology, Washington, DC), and HAROLD ANDREWS AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 20 p. refs
(AIAA PAPER 90-3240) Copyright

This paper discusses the history of the North American Rockwell XFV-12A Thrust Augmented Wing VSTOL aircraft program, covering both technical development and programmatic factors that contributed to its unsuccessful outcome. Within this context, both technical achievements and failures are noted. Reflections on the interplay of events and some lessons derived from the program experience complete the paper. Author

A90-49119#

THE DESIGN OF A SPORT AIRCRAFT CONFIGURED TO EMULATE JET FIGHTER CHARACTERISTICS

TERRY L. HARRELL (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations

Conference, Dayton, OH, Sept. 17-19, 1990. 21 p. refs
(AIAA PAPER 90-3244) Copyright

The design philosophy and evolution of an advanced light aircraft concept configured to emulate jet fighters are presented. The objective of the configuration study is to develop an affordable, highly maneuverable aircraft which presents to its pilot key jet fighter cues in the areas of external appearance, cockpit environment, handling qualities, and to the maximum extent practical, performance. Central to the success of the concept is the ability to perform the air combat maneuvers and tactics of current jet fighters such as the F-16 and F-18. The design evolution of the current configuration is discussed, with emphasis on high angle of attack aerodynamics and controllability. The design development of the cockpit and airframe structure are also presented, along with a summary of the current baseline's operational capabilities and cost. Author

A90-49124#

STOVL OPTION FOR THE MULTI-ROLE FIGHTER

Y. T. CHIN, L. P. DODD, and J. E. DURRIE (Lockheed Aeronautical Systems Co., Burbank, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. Research supported by Lockheed Independent Research and Development Program. refs
(AIAA PAPER 90-3296) Copyright

Future Air Force multi-role fighter (MRF) design drivers are the required missions and operational concepts. Notional preliminary MRF missions are Battlefield Air Interdiction (BAI) and Defensive Counter Air (DCA). For these missions, the MRF is postulated to have the capability for short takeoff and vertical landing (STOVL). The STOVL option for the MRF is attractive because of greater accessibility of operating bases and sortie generation following airfield attack. Availability of thrust vectoring in forward flight (VIFF) in some STOVL concepts could also be used to enhance the combat effectiveness. For the MRF/STOVL, notional design goals were derived from 'strawman' operations concepts. A unique MRF/STOVL design based upon the Reverse-Installation Vektored Engine Thrust (RIVET) propulsion concept is discussed. Author

A90-49125*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SELECTED DESIGN ISSUES OF SOME HIGH SPEED ROTORCRAFT CONCEPTS

PETER D. TALBOT, JAMES D. PHILLIPS, and JOSEPH J. TOTAH (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 30 p. refs
(AIAA PAPER 90-3297) Copyright

A study of vehicle concepts for High Speed Rotorcraft applications has been undertaken at Ames Research Center in cooperation with NASA Lewis and Langley Centers, with the objective of defining their technology needs. The design guidelines include a low downwash velocity in hover, good low speed maneuver capabilities and cruise speeds up to 450 knots. Four contractors and a systems analysis effort within NASA have defined promising configurations which may be capable of meeting these goals. This paper addresses challenging problems associated with some of the configurations in the areas of aerodynamics, propulsion, weights and aeroelastic stability. Author

A90-49292

AUTOMATIC ENVIRONMENTAL CONTROL SYSTEM FOR ELECTRONIC EQUIPMENT PLATFORMS

JAMES E. BURKHARDT (E-Systems, Inc., Greenville, TX) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 8 p. Research supported by USAF.
(SAE PAPER 901217) Copyright

Many advances in the electronics and electronics packaging industries have recently increased the heat load densities of electronic equipment. For older cargo aircraft which have been modified into electronic equipment platforms, the introduction of the higher heat load density boxes along with large variations in

flight profiles and equipment duty cycles have rendered many low pressure bleed air environmental control systems incapable of providing sufficient cooling. This paper describes an automatic environmental control system (AECS) which is designed to use the available ECS air supply more effectively and to conserve bleed air. The system gathers temperature sensor data and analyzes the cooling requirements of the aircraft. Valves, acting as variable orifices in the aircraft distribution ducting, are then positioned to provide air to the equipment with the greatest need. Author

A90-49293

AIRCRAFT SUBSYSTEM WASTE ENERGY RECOVERY AND MANAGEMENT

RALPH L. HERRING and PATRICK K. COLLINS (McDonnell Aircraft Co., Saint Louis, MO) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 21 p. refs
(SAE PAPER 901218) Copyright

Subsystem environmental/thermal control is a vital process in the overall integration of processes leading to quality operational aircraft. Providing control of the required environments and subsystem component temperatures is accomplished. However, current aircraft environmental control/thermal control system design does not attempt to recover or utilize waste thermal energy. Creative methods to control and use the waste thermal energy will enhance aircraft performance. Unless efficient energy recovery and conversion systems are developed and integrated with the other aircraft subsystems it will be found difficult to achieve full performance potential in new aircraft. Author

A90-49294

USE OF ECS-CONDITIONED AIR FOR FLIR AVIONICS THERMAL CONTROL - FIGHTER AIRCRAFT

DONALD C. PRICE (Texas Instruments, Inc., Defense Systems and Electronics Group, Dallas, TX) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 33 p. refs
(SAE PAPER 901219) Copyright

Problems with the allocation of environmental-control system (ECS) chilled air for the thermal control of avionics systems are considered, with emphasis on the design of a thermal control system for an air-cooled forward-looking infrared (FLIR) system for a high-performance fighter aircraft. Two methods of allocating cooling air to avionics systems are compared. Pressure-drop and thermal analyses performed on line-replaceable units (LRU) in an FLIR are discussed. ECS specifications for a FLIR are outlined, and the aerodynamic heat load on an LRU is estimated. The design parameters of heat exchanges and coldwall is presented, along with differences in sea-level and high-altitude flight design conditions. It is concluded that the approach used on the example FLIR system allows the system to operate within the specifications and achieve all of the stated design goals. V.T.

A90-49295

X-29 ECS HIGH-ALPHA MODIFICATIONS

MARGARET ERIAS AMALFITANO (Grumman Corp., Aircraft Systems Div., Bethpage, NY) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 10 p.

(SAE PAPER 901221) Copyright

It was anticipated that during X-29 extended duration, high angle-of-attack flight (40 to 70 deg), aircraft ECS performance would significantly degrade. Computer modeling of the system indicated that the performance of the ECS decreased as the angle of attack increased. Modifications to improve system performance were analyzed and, as a result of this analysis, ECS hardware modifications have been incorporated on the aircraft. The High-Alpha Flight Test Program has proven the validity of these modifications. To date, the ECS on Ship No. 2 has performed well within its nominal operating parameters in the high-alpha regime. Author

A90-49304**PROVEN DYNAMIC MODELING TECHNIQUES FOR CONCURRENT DESIGN AND ANALYSIS OF ECS CONTROLLERS**

J. P. LASTER, M. J. MAXWELL, and J. E. GARNER (General Dynamics Corp., Fort Worth, TX) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 19 p.

(SAE PAPER 901234) Copyright

An F-16 environmental control system (ECS) computer model has been developed for the design and development of ECS control algorithms. Model descriptions, modeling techniques, verification results, test-stand data reduction and comparison, and a comparison with flight-test data are presented. The ECS model has been constructed with component modules that mimic the dynamic characteristics of their physical counterparts; thus the system model can then mimic the physical system. This approach satisfies the requirement for a comprehensive nonlinear mathematical model to accurately describe system dynamics. ECS model accuracy verification was accomplished by comparing analysis results to F-16 FCS test-stand data and F-16C flight-test data. Results of this model verification indicate that the FCS computer model can accurately represent the frequency response of internal control loops and the transient response of the ECS.

R.E.P.

A90-49305**F-15 ENVIRONMENT CONTROL SYSTEM IMPROVEMENTS**

SHARON K. RYAN (McDonnell Aircraft Co., Saint Louis, MO) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 10 p.

(SAE PAPER 901235) Copyright

The continuing development of the F-15 has included improvements to its baseline Environment Control System (ECS), an open air cycle system built around a bootstrap air cycle machine. A simple air controller schedule change and the conversion to a High Pressure Water Separator (HPWS) ECS were steps in the evolution of the F-15 ECS which yielded gains in avionics cooling capacity of about 63 percent. Recent modifications of the F-15E aircraft to accommodate the Increased Performance Engine (IPE) have included ECS changes to maintain the capacity gains achieved previously. Another modification of the F-15E which expands ECS capabilities is a Molecular Sieve Oxygen Generating System (MSOGS) which will be incorporated on all IPE aircraft. This paper discusses the evolution of the F-15 ECS which includes (1) conversion to a HPWS ECS and optimization of the cooling air distribution system, and (2) current modifications to accommodate IPE and MSOGS.

Author

A90-49306**FOIL GAS BEARINGS FOR TURBOMACHINERY**

G. L. AGRAWAL (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 11 p.

(SAE PAPER 901236) Copyright

Hamilton Standard has developed and patented a new generation of foil journal and thrust bearings for use in high speed turbomachinery. These bearings are presently being used and are in production for air cycle machines used in environmental control systems on many civil and military aircraft. On the Boeing 747 aircraft, the foil bearing air cycle machines have accumulated over one million flight hours. The latest model 747 foil bearing air cycle machine has demonstrated an MTBF (mean time between failure) in excess of 100,000 hours. The present paper describes the Hamilton Standard journal and thrust foil bearing concept, its advantages, and its applications. Planned work to be pursued in the near future is also described.

Author

A90-49307**EVALUATION AND CONTROL OF AN INTEGRATED CLOSED ENVIRONMENTAL CONTROL SYSTEM (ICECS)**

JON M. EDGAR (Allied-Signal Aerospace Co., Los Angeles, CA)

and BRIAN CAMPBELL (Garrett Canada, Rexdale) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 18 p. Research supported by USAF and Industry, Science, and Technology Canada.

(SAE PAPER 901237) Copyright

The Integrated Closed Environmental Control System (ICECS) Program included design, analysis, fabrication and testing of an advanced environmental control system concept for military aircraft. Fuel was utilized as the primary heat sink of a vapor-cycle system with ram air augmentation. Through the use of closed-loop avionics cooling and maximum use of fuel as a heat sink, reductions in bleed air use reduced environmental control system (ECS)-related fuel penalties and, as a result, reduced life-cycle costs (LCC). Additionally, by providing a drier, more stable environment for avionics, significant reliability gains have been demonstrated when compared to the baseline open-loop ECS. The overall emphasis was to verify through test the benefits of an ICECS using primarily off-the-shelf hardware.

Author

A90-49308**ENHANCED ENVIRONMENTAL CONTROL FOR THE HARRIER II PLUS**

MYRON O. EASON (McDonnell Aircraft Co., Saint Louis, MO) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 11 p.

(SAE PAPER 901238) Copyright

Environmental control system improvements planned for a radar equipped AV-8B aircraft are presented. The aircraft, designated the Harrier II Plus, is a joint venture of McDonnell Aircraft Company and British Aerospace Corporation with the USMC and several foreign customers in mind. The principle aircraft change is the addition of the AN/APG-65 multi-mode radar. This radar, along with other Harrier II Plus cooling requirements, imposes a nine-fold increase in the aircraft's avionics cooling requirement. Extensive changes to the aircraft's two environmental control systems resulted and are presented herein. Topics covered include: (1) current AV-8B ECS configuration, (2) Harrier II Plus design requirements, (3) bleed circuit changes, (4) heat sinks, (5) ECS packages, (6) avionics cooling control, (7) liquid cooling system, and (8) ground cooling provisions. The changes identified will increase the aircraft's cooling capacity from 12 kw to 21 kw.

Author

A90-49477**ATF PROTOTYPES OUTSTRIP F-15 IN SIZE AND THRUST**

MICHAEL A. DORNHEIM Aviation Week and Space Technology (ISSN 0005-2175), vol. 133, Sept. 17, 1990, p. 44-46, 49, 50.

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Estimated comparative characteristics are provided for the YF-22A, YF-23A, and the F-15C. The similarities in wingspans, but with 35-55 percent more area and planforms in the ATF prototypes that are tuned for low radar observability and structural efficiency, are defined. The most striking technical advance is in the engines that are in the 35,000/lb thrust class in afterburner as compared to the 23,450/lb thrust of the F-15C at similar weights. Thrust is also increased in the high-speed, high-altitude section of the flight envelope, which permits the ATF to cruise at Mach 1.4-1.5 without afterburner. The new engines also have better specific fuel consumption and improved maintainability and reliability. Ordnance and auxiliary fuel tanks fit inside the ATF as opposed to the external carriage of an F-15. Five major characteristics are listed for the ATF: low observables, high maneuverability, supersonic cruise at military thrust, adequate payload, and sufficient range for all theaters of operation. R.E.P.

A90-49488**AEROSTRUCTURAL CONSIDERATIONS FOR THE POWER PLANT OF OVERLAPPING WING CONFIGURATION**

M. A. Y. KAMAL and S. A. HASAN (Pakistan International Airlines Corp., Training Centre, Karachi) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York,

International Academic Publishers/Pergamon Press, 1990, p. 503-510. refs
Copyright

A study is presented which is part of a larger investigation of overlapping wing aircraft concept. The NASA/Lockheed trisonic biplane design was used to evolve a new configuration. Particular attention is given to the selection of the propulsion system position.
K.K.

A90-49823

GRIPEN WINS ITS WINGS

ERIC BEECH Flight International (ISSN 0015-3710), vol. 138, Sept. 11, 1990, p. 90-93, 95, 96.
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The Swedish JAS39 Gripen has resumed flight testing and development. Eventual production by 1993 is intended to replace all of the Saab 37 Viggen and J35 Drakens in the air force with a truly multirole all-weather, all-altitude supersonic fighter. In today's environment the Gripen is unusual in having only a single engine as opposed to the twin-engined fighters of other countries. The overriding requirement was to reduce weight and maximize performance so that a single engine with inherent growth potential would be sufficient. This RM12 engine is a twin-shaft, low-bypass-ratio afterburning turbofan developing 80 kN of thrust. A triple-redundant digital fly-by-wire (FBW) flight control system using an aircraft motion sensor and throttle actuator subsystem is installed, and a single-channel analog backup system is included in case of complete failure of the FBW system. Avionics systems details are provided along with a descriptive cutaway diagram of the aircraft.
R.E.P.

A90-49824

COMMUTER FROM KHODINKA

ALAN POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 138, Sept. 11, 1990, p. 100-104, 107.
Copyright

The Soviets are developing and flight-testing a new regional airliner, designated the Il-114, for service introduction in 1992. Specifications call for 60 seats, a range of 1,000 km with a 5.4 ton payload, 270 kt cruise speed at 26,000 ft, and a 4,600 ft runway capability. It must also be able to use unprepared landing strips, and to have low noise and low fuel consumption. Composite materials are used in the dorsal fin, ailerons, spoilers, wing-root fairings, radome, and cabin floor. The powerplant is a TV-117 turboprop twin-spool engine comprising a five-stage axial and single-stage centrifugal compressor with two high-pressure and two low-pressure turbine stages. The weight of the engine is 420 kg dry and it is rated at 1,800 kw. Additional details are provided on avionics and performance along with a cutaway diagram of the aircraft.
R.E.P.

A90-49825

STARSHIP SAILS THROUGH

Flight International (ISSN 0015-3710), vol. 138, Aug. 29, 1990, p. 24-27.
Copyright

The unconventional appearance of Starship 1 encompasses an all-composite airframe, tandem-wing aerodynamics and miniaturized digital avionics. Two PT6A-67A pusher turboprops provide 1200 shp at takeoff. Composite structure is smooth but there are aerodynamic appendages to improve performance in extreme portions of the flight envelope. The end of the wing has four 'vortilons' under the leading edge, to smooth airflow at high angles of attack, and a stall-break strip inboard. The all-CRT instrumentation in the cockpit comprises electronic attitude-director and horizontal situation indicators arranged vertically, engine monitors and crew alerting system and malfunction display screens. Comparative figures are provided on weights and performance with other business aircraft. The Starship's handling and performance in flight are described.
R.E.P.

A90-49836#

LIGHTNING TESTING AND TEST ANALYSES OF THE JAS39 AIRCRAFT

HANS M. FRENNEBERG, BENGT A. OLSSON, BO I. WAHLGREN (Saab-Scania AB, Linköping, Sweden), MARTIN LUTZ, and MARTIN MODRUSAN (Emile Haefely und Cie. AG, Basel, Switzerland) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 144-149.

This paper describes the verification and test philosophy, test setup, analytical models, and diagnostic system for the JAS39 aircraft. The test setup consisted of the aircraft placed in a return conductor system made of copper conduits, a specially designed lightning generator, a diagnostic system, and a shielded compartment. The diagnostic system was programmed to perform a complete evaluation of test results, including necessary probe compensation and extrapolations during testing.
C.D.

N90-26807# Air Force Wright Aeronautical Labs., Langley AFB, VA. Materials Lab.

PROCEEDINGS OF THE 1987 AIRCRAFT/ENGINE STRUCTURAL INTEGRITY PROGRAM (ASIP/ENSIP) CONFERENCE Final Report, Dec. 1987 - Mar. 1988

JOHN W. LINCOLN and THOMAS D. COOPER Jun. 1988
914 p Conference held in San Antonio, TX, 1-3 Dec. 1987 (Contract AF PROJ. 2418)
(AD-A198037; AFWAL-TR-88-4128) Avail: NTIS HC A99/MF E06 CSCL 01/2

Topics addressed include: composite structures; metallic structures; mechanical subsystems integrity program (MECSIP)/engine structural integrity program (ENSIP); materials/tracking; HSIP/analysis/methods; and instruments/tracking.

N90-26808# Northrop Corp., Hawthorne, CA.

LESSONS LEARNED FOR COMPOSITE AIRCRAFT STRUCTURES QUALIFICATION

In AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 9-43 Jun. 1988
Avail: NTIS HC A99/MF E06 CSCL 01/2

An overview of the extensive experience, lessons learned, and recommended certification procedures from two major USAF composite research and development programs is presented. Subject areas discussed in detail are static strength, fatigue/durability, and damage tolerance.
Author

N90-26810# McDonnell-Douglas Corp., Saint Louis, MO. Structural Research Dept.

AN EXPERT SYSTEM ADVISOR FOR DAMAGE REPAIR OF COMPOSITE WING SKINS (REPAIRMAN)

HERB SMITH, JR., CHARLES SAFF, and TOM CHRISTIAN (Warner Robins Air Logistics Center, Robins AFB, GA.) In AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 53-61 Jun. 1988
Avail: NTIS HC A99/MF E06 CSCL 01/2

Temporary repair of battle-damaged composite wing skins is addressed by an expert system advisor that produces a bolted patch design suitable for the next mission requirements of the aircraft. The repair methodology utilized was developed under Air Force contract and addresses the temporary repair of damage holes up to seven inches in diameter using bolted patches of aluminum or steel sheets. The patch materials are available in the standard aircraft repair kit.
Author

N90-26812# Air Force Systems Command, Wright-Patterson AFB, OH. Aeronautical Systems Div.

LESSONS LEARNED FROM THE T-46A DURABILITY AND DAMAGE TOLERANCE PROGRAM

HSING C. YEH In AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP)

Conference p 280-310 Jun. 1988

Avail: NTIS HC A99/MF E06 CSCL 11/4

The T-46A durability and damage tolerance program accomplishments through full scale engineering development are presented. The T-46A design criteria, analysis, development test, and the full scale durability test are discussed. A detail discussion of the findings of the pre-production design verification (PDV) tests, full scale durability test and proposed design changes to be incorporated in the production articles are described. Special manufacturing processes such as application of cold work, installation of interference fasteners are also presented. Lessons learned from the program are discussed in detail. It is believed that use of the lessons learned will significantly reduce durability and damage tolerance technical risk, for future structural integrity programs. Author

N90-26813# Pratt and Whitney Aircraft, West Palm Beach, FL. Advanced Engineering Operations.

RETIREMENT FOR CAUSE OF THE F100 ENGINE

JOHN A. HARRIS, JR. and M. C. VANWANDERHAM /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 515-529 Jun. 1988

Avail: NTIS HC A99/MF E06 CSCL 11/4

Retirement for cause (RFC) is a life cycle management procedure for gas turbine engine components, such as fan, compressor and turbine disks. The procedure enables full use of the safe life inherent in each component, as opposed to arbitrary retirement from service of all components at a calculated low cycle fatigue life. Historically, these components have been retired at the accumulated time (or cycles) where the first fatigue crack in 1000 identical components, all used in an identical manner, could be expected to occur. By definition then, 99.9 percent of these components were being retired prematurely, while they still may have had useful life remaining. The retirement for cause approach is based on fracture mechanics and nondestructive evaluation, and is evaluated economically. The U.S. Air Force recognized the potential of this approach for maintenance life cycle cost savings and began development programs in the late 1970s and early 1980s to reduce the RFC concept to practice. Those programs have been successfully completed. The development and integration of the methodology, its implementation for 23 USAF F100 engine components by the San Antonio Air Logistics Center, and its economic and other benefits are discussed. Author

N90-26815# Lockheed-Georgia Co., Marietta.

COMPUTERIZED CORROSION FORECASTING MODEL FOR C-5 AIRCRAFT

ROBERT N. MILLER and FRED H. MEYER (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.) /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 543-564 Jun. 1988

(Contract F33615-85-C-5058)

Avail: NTIS HC A99/MF E06 CSCL 11/4

A predictive corrosion model which will enable optimum corrosion maintenance scheduling for C-5 aircraft is being developed. The VAX-2 computer program is based on the kinetics of corrosion of aircraft alloys and upon the environmental conditions existing at Air Force bases. When completed, it will provide a fully integrated method for predicting crack growth, corrosion damage, and coating degradation for C-5 aircraft operating in a variety of environments. The corrosion model is being validated by comparing predicted crack lengths with actual crack lengths in the test article used in the C-5A modified wing structural test evaluation and by comparing predicted corrosion damage with corrosion control man-hours expended on selected areas of the C-5B aircraft. In the cracks analyzed to date, the predicted crack lengths are very close to the actual lengths. With only minor modification, the predictive corrosion modeling program may be used for the C-141, C-130, B-52 or any other aircraft fleet which already has a crack monitoring program in operation. Author

N90-26816# Aluminum Co. of America, Davenport, IA.

AN ALUMINUM QUALITY BREAKTHROUGH FOR AIRCRAFT STRUCTURAL RELIABILITY

C. R. OWEN, R. J. BUCCI (Aluminum Co. of America, Alcoa Center, PA.), and R. J. KEGARISE /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 565-591 Jun. 1988

Avail: NTIS HC A99/MF E06 CSCL 11/4

In 1983 Alcoa's Davenport Works initiated a statistically design experiment to evaluate effects of metal processing on thick plate metal quality. An outgrowth of this program has been a breakthrough in quality and resultant property improvements that can be exploited for fatigue and fracture critical structures. The statistical quality control effort is described and evidence is given the improved capabilities typical of recently produced high quality material. Among conventional mechanical property tests, the smooth fatigue test is shown to be the most discriminating for initial metal quality. Data are shown correlating longer lifetimes to reduced microporosity size in the improved plate. Replicate fatigue tests enable definition of a characteristic initial flow size distribution which can serve as a starting point for flaw growth analysis and life management. These findings are discussed relative to initial fatigue quality guarantees and compatibility with emerging U.S. Air Force durability analysis methodology. In summary, it is shown that the combination of more discriminating testing and a superior product offers considerable promise for reliability improvement in aircraft structural designs of the future. Author

N90-26817# Sikorsky Aircraft, Stratford, CT.

APPLICATION OF DAMAGE TOLERANCE

GEORGE J. SCHNEIDER /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 593-614 Jun. 1988

Avail: NTIS HC A99/MF E06 CSCL 01/3

Sikorsky Aircraft has been under contract since late 1982 to investigate the application of damage tolerance to the H-53 helicopter. This program has involved identification of critical structure, usage spectrum evaluation, loads evaluation, detail stress analyses, material and verification testing, and development of stress intensity solutions. The primary objectives of the program were to develop a computer program for use by Sikorsky and Warner Robins-ALC to perform crack growth analysis of helicopter structure, to evaluate crack growth in a select group of rotor and airframe structure, and to assess the feasibility of damage tolerance force management for the H-53 Air Force fleet. A presentation was made at the 1984 Aircraft Subsystems Integrity Program (ASIP) conference to provide an introduction to this program. Since then Sikorsky has completed an initial crack propagation analysis of a select group of rotor and airframe structure. The purpose of this presentation is to review some of the technical issues involved in the crack growth analysis, to present some of the analysis results, and to review conclusions and lessons learned. Author

N90-26818# Sikorsky Aircraft, Stratford, CT. Diagnostics.

INDIVIDUAL HELICOPTER TRACKING PROGRAM (IHTP) FOR THE MH-53J HELICOPTER

JOHN G. B. DANIELL /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 615-639 Jun. 1988

Avail: NTIS HC A99/MF E06 CSCL 01/3

The cost and complexity of maintaining aircraft in the Air Force inventory escalates with time. New methods are required to increase the cost effectiveness of fleet aircraft maintenance while simultaneously decreasing down time and improving readiness rates. A system is being developed which can collect details of usage of each helicopter in the fleet automatically. The resulting data base can then be used in conjunction with analytical processes to determine component inspection intervals using Damage Tolerance Assessment (DTA) techniques. This will replace the present assumption of one universal usage spectrum for all, regardless of the actual usage of individual aircraft. The helicopter peculiar aspects of component life estimation and the present

methodology will be reviewed. The new system will be described and the process involved will be outlined. Author

N90-26820# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.

FINITE ELEMENT MODELS OF USAF AIRCRAFT STRUCTURES

JAMES J. OLSEN and VIPPERLA B. VENKAYYA /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 655-671 Jun. 1988
 Avail: NTIS HC A99/MF E06 CSCL 01/3

Finite element analysis is at present an industry standard for the analysis and design of aerospace structures. Significant resources are expected to be allocated for developing, testing and validating finite element models (FEMS) of current and the future USAF aircraft. The premise is that the effective use of finite element analysis can reduce (not eliminate) dependence on test procedures which are very costly both in time and resources. However, there is a lot to be desired from the way industry and Government organize and perform finite element analysis. The major deficiency is the lack of a clear definition of the analysis objectives and tailoring the models to achieve the goals in a most economical and reliable way. An even more disturbing fact is that, at present, industry developed finite element models are a wasted effort as far as future utility is concerned, because the Air Force does not take delivery of these models in an organized, predictable way. Hence, various potential users of FEMS throughout USAF do not know if and where the FEMS exist and how to gain access and use them. The result can be a duplication of developments and an unnecessary cost to the USAF. Various cost-effective ways of taking delivery of finite element model data and establishing procedures for archiving, communicating, retrieving and validating in a secure environment are explored. It also delineates the cost and performance benefits that can be derived during the life of an aircraft by maintaining an accurate and readily available library of finite element models of USAF aircraft. Author

N90-26821# Southwest Research Inst., San Antonio, TX.

AUTOMATED ANALYSIS OF MXU-553 FLIGHT DATA

KURT H. SCHRADER /in AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 793-818 Jun. 1988
 Avail: NTIS HC A99/MF E06 CSCL 01/3

As part of the aircraft structural integrity program developed by the U.S. Air Force, different types of aircraft have been involved in a flight data recording program for many years. Software for analyzing the data recorded by the MXU-553 equipped aircraft, for generating spectra and profile information, and to display the resulting data were developed. This software was designed to process not only the MXU-553 data but also the data from the micro-processor recorders being developed at this time. Once all software had been written, a final requirement of the contract with the Air Force was to process many hours of MXU-553 data and report the results. The programs developed for San Antonio Air Logistics Center (SA-ALC/MMSA) are summarized in the interaction overview. The first program consists of a compression effort where the raw MXU-553 data is converted to engineering units and compressed to retain only significant flight data. This compressed flight data is processed by SA-ALC using the edit/pre-analysis program which allows for tabular and graphic display of data and editing of erroneous information. The final program permits the tabulation of spectra and profile information and is named SOUP (Spectra and Operational Usage Profile). This program is the subject of this presentation. Author

N90-26822# Air Force Wright Aeronautical Labs., Langley AFB, VA.

PEAK IDENTIFICATION TECHNIQUES

/in its Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 819-844 Jun. 1988
 Avail: NTIS HC A99/MF E06 CSCL 01/3

Peak identification is performed, primarily for flight measured data, to reduce the amount of information which must be considered

for structural life analyses. The peak identification methodology applied defines those points in time, and therefore limits the measured data, for which further analysis will be performed. Ideally, the peak identification technique used will retain all stress cycles which contribute to structural damage while eliminating those times within an aircraft's life which are unimportant in a structural sense. This peak identification techniques presentation is limited to a discussion of methods by which peak maneuver response times are established. The presentation does not discuss ordering techniques such as range-pair or rain-flow. Additionally, the presentation primarily addresses fighter, attack, and fighter-trainer aircraft. Although examples and discussions are based on these limitations the concepts presented have implications across a broad range of applications. The peak identification techniques presentation concentrates on three established methods of peak identification. These methods are known as Conventional Count or 50 percent Rise-Fall, Range-Pair or Fixed Increment, and Counting Accelerometer or Fixed Return. Author

N90-26824*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.

THE SKY SHARK: AN RPV DESIGNED TO INVESTIGATE THE PRESSURE DISTRIBUTION ON A LIFTING SURFACE Final Design Proposal

ROB ZIEMBA, JOE SCHUDT, KAREN COMLY, MIKE VANTHOURNUT, JEROME C. TRYBUS, GREG BRANCH, MAGGIE HASSAN, STEVE NOLL, STEVE JULIAN, and DAVE CAREY 4 May 1989 176 p
 (Contract NASW-4435)
 (NASA-CR-186222; NAS 1.26:186222) Avail: NTIS HC A09/MF A01 CSCL 01/3

The objective was to design a remotely piloted vehicle which is capable of gathering in-flight pressure distribution data on a lifting test specimen, and then test the design by constructing a subscale demonstrator, to prove the flight worthiness of the concept. The technology demonstrator was scheduled for takeoff at approximately, 7:20 AM on Thursday April 27th. There was a light wind from the southeast. The plane was hand-launched and made an initial dip, most likely due to the poor trim conditions at launch. It then began to climb and bank into a left turn. The aircraft climbed to an altitude of approximately 150 ft and circled. The plane flew for several minutes and at times appeared to bump around, which was due to thermal activity disrupting the flight of the aircraft. The aircraft was brought slowly down in a power-off condition and glided in for a belly landing and landed without incident. Results of the flight test proved the general capability of the design to maintain flight stability throughout the take off, cruise, turning, and landing flight regimes. We were not able to demonstrate stability with the test specimen in place as the control surfaces designed to counteract the instabilities induced in the static system, winglets and ailerons, were not included. Author

N90-26825# Aerospace Medical Research Labs., Wright-Patterson AFB, OH. Biodynamics and Bioengineering Div. **BASEOPS DEFAULT PROFILES FOR CIVIL AIRCRAFT Interim Report, Jul. - Sep. 1989**

ROBERT A. LEE Sep. 1989 94 p
 (Contract AF PROJ. 7231)
 (AD-A223161; AAMRL-TR-90-009) Avail: NTIS HC A05/MF A01 CSCL 12/5

This report describes the default Power Setting/Airpeed/Altitude Profiles for Civil Aircraft takeoffs and landings that are used in the USAF BASEOPS program. BASEOPS is a computerized operations input program for Airbase Noise analyses done under the AF AICUZ program. These takeoff and landing profiles were selected from the FAA Integrated Noise Model (INM) database 9 profiles. The most used stage length for each aircraft was selected to model each takeoff profile. The landing profiles were modeled directly from the INM database. Use of these profiles with the USAF NOISEMAP program should yield similar noise exposure values to the results obtained from the FAA INM program. GRA

N90-26826# McDonnell Aircraft Co., Saint Louis, MO.
**DAMAGE TOLERANCE ANALYSIS FOR MANNED
 HYPERVELOCITY VEHICLES. VOLUME 2: SOFTWARE USER'S
 MANUAL Final Report, Sep. 1986 - Sep. 1989**

D. M. HARMON and C. R. SAFF Sep. 1989 164 p
 (Contract F33615-86-C-3208; AF PROJ. 2401)
 (AD-A222136; WRDC-TR-89-3067-VOL-2) Avail: NTIS HC
 A08/MF A01 CSCL 11/6

The objective was to provide a fracture mechanics based life prediction procedure for hypersonic airframe structures subjected to combined mechanical loadings and thermal profiles. Existing routines were used along with element test data to develop this procedure. Accuracy of the procedure was determined by predicting the crack growth under thermomechanical load histories typical of advanced fighters and aerospace vehicles, and then comparing those predictions with test results. Limitations in the ability of this procedure to predict the test results were used to formulate recommendations for further modeling efforts and research. A fracture mechanics based life prediction procedure was developed for hypersonic airframes subjected to thermomechanical load profiles. The analysis that was developed models crack growth behavior in metals, accounts for the effects of temperature on yield strength and fracture toughness, and includes the effects of sustained loads at elevated temperature on crack growth rate. The analysis was incorporated into a computer routine named DAMAGE. Predictions made with the DAMAGE routine were within 20 percent of the test lives for 67 percent of the combined thermomechanical load history tests performed. GRA

N90-26827# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.

**MODEL TILT-ROTOR HOVER PERFORMANCE AND SURFACE
 PRESSURE MEASUREMENT**

CHEE TUNG and LONNIE BRANUM May 1990 12 p Presented at the 46th Annual Forum of the American Helicopter Society, Washington, DC, May 1990

(AD-A22535) Avail: NTIS HC A03/MF A01 CSCL 01/3

A test of a small scale 3-bladed model rotor, with geometry typical of that used on tilt rotor aircraft, was conducted in the Army Aeroflightdynamics Directorate's anechoic hover chamber. The purpose was to determine the hover performance of the rotor and investigate the pressure distributions on a blade at various collective pitch angles and tip speeds. The measured pressures indicate that the rotor did not stall for high collective pitch angles up to theta sub c = 25 deg. This is clearly a 3-D effect since 2-D theory predicts flow separation at these high angles. The flow near the trailing edge separated above theta sub c = 25 deg which caused a sharp increase in power. GRA

N90-26828# Dayton Univ., OH. Research Inst.
**B-1B IMPROVED WINDSHIELD DEVELOPMENT. VOLUME 2:
 MAGNA ANALYSIS: BASELINE AND PARAMETRIC Interim
 Report, Jun. 1987 - Sep. 1988**

MICHAEL P. BOUCHARD and WILLIAM BRAISTED Feb. 1990 145 p
 (Contract F33615-84-C-3404; AF PROJ. 1926)
 (AD-A221501; UDR-TR-88-129-VOL-2; WRDC-TR-89-3123-VOL-2)
 Avail: NTIS HC A07/MF A01 CSCL 01/3

This report documents analyses which supported a study aimed at eliminating B-1B windshield problems which surfaced when the aircraft became operational. Optics and durability were immediately degraded by delamination. The many edge attachments made windshield changeout difficult and time-consuming, thereby affecting supportability. The objective of these analyses was to evaluate the impact of design configuration changes proposed to alleviate the in-service problems on the structural performance of the windshield system when subjected to birdstrike or internal cabin pressure. The MAGNA finite element analysis code was used to evaluate the structural performance of the current production configuration, which served as a baseline, and the alternate design configurations. The fasteners were evaluated based on MAGNA output using additional computer programs. Computations were made first assuming all fasteners were present,

then assuming every other fastener was removed. The models and analyses are discussed and summary results for each design configuration presented. Conclusions are drawn regarding the viability of the proposed alternate design configurations in view of their impact on the structural performance of the windshield system. GRA

N90-26829# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.

**SPECIAL ESSAYS FOR THE 40TH ANNIVERSARY OF THE
 REVOLUTION: THE CHIEF DESIGNER DISCUSSES THE F-8 2
 AND FUTURE FIGHTER PLANES**

YAWEI WANG 30 Mar. 1990 15 p Transl. into ENGLISH from Guoji Hangkong (Peoples Republic of China), no. 5, May 1989 p 6-8

(AD-A221587; FTD-ID(RS)T-1296-89) Avail: NTIS HC A03/MF A01 CSCL 01/3

The chief contribution of the F-8 II is an increase in combat strength. The discussion naturally began with the F-8 II, for whose development Chief Gu had been responsible. The prototype of the F-8 had been under development since 1964, and made use of the aerodynamic design of the similar F-7, using however a double engine layout. The main performance requirements were excellent high-altitude, high-speed capabilities, a relatively long range, and a relatively high rate of climb. In 1966, the preliminary stage of design was complete; on 5 July 1967 the prototype made its successful maiden flight, and the plane was delivered for use. The development of the prototype was a victim of the ten turbulent years, so the road to success was rough. The F-8 II is a new model fighter developed on the foundation of the F-8 prototype; it made its maiden flight on 12 June 1984. Its design has been finalized, and it is now in production. GRA

N90-26830# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Cascina Costa (Italy). Div. Elicotteri.

**DEVELOPMENT OF A METHOD TO DESIGN HELICOPTER
 ROTORS [SVILUPPO DI UNA METODOLOGIA DI
 PROGETTAZIONE DI PROFILI PER PALE DI ELICOTTERI]**

ANDREA BIASIOL and GIUSEPPE PAGNANO 16 Oct. 1989 7 p In ITALIAN

(REPT-100-30-03; ETN-90-97271) Avail: NTIS HC A02/MF A01

The development of a computer code for the optimization of helicopter wing design is briefly described. It is shown that first order methods are best adapted to the optimization procedures. The possibility of adopting a multiple non-linear regression to obtain an analytical surface for a fast first optimization is discussed. ESA

N90-27694*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.

**A TWO DIMENSIONAL STUDY OF ROTOR/AIRFOIL
 INTERACTION IN HOVER**

CHYANG S. LEE Aug. 1988 35 p Sponsored by NASA, Ames Research Center

(NASA-CR-183272; NAS 1.26:183272; SU-JIAA-TR-88) Avail: NTIS HC A03/MF A01 CSCL 01/3

A two dimensional model for the chordwise flow near the wing tip of the tilt rotor in hover is presented. The airfoil is represented by vortex panels and the rotor is modeled by doublet panels. The rotor slipstream and the airfoil wake are simulated by free point vortices. Calculations on a 20 percent thick elliptical airfoil under a uniform rotor inflow are performed. Variations on rotor size, spacing between the rotor and the airfoil, ground effect, and the influence upper surface blowing in download reduction are analyzed. Rotor size has only a minor influence on download when it is small. Increase of the rotor/airfoil spacing causes a gradual decrease on download. Proximity to the ground effectively reduces the download and makes the wake unsteady. The surface blowing changes the whole flow structure and significantly reduces the download within the assumption of a potential solution. Improvement on the present model is recommended to estimate the wall jets induced suction on the airfoil lower surface. Author

N90-27697# National Aeronautical Establishment, Ottawa (Ontario).

A REVIEW OF CRASHWORTHINESS OF COMPOSITE AIRCRAFT STRUCTURES

C. POON Feb. 1990 42 p
(AD-A221555; NAE-AN-63; NRC-31276) Avail: NTIS HC A03/MF A01 CSCL 01/3

A review of major research activities in North America with respect to the crashworthiness of composite aircraft structures was performed with the goal of identifying potential Canadian contribution to R and D areas where effort would be required to complement the on-going programs in the United States. Recommendations include a study on the effect of aircraft size on crashworthiness design requirements; the implementation of the KRASH code in Canada to establish commonality in analytical methods with major U.S. and European users; an investigation on the energy absorption capabilities of the design features for small aircraft containing composite and/or composite/hybrid structures; and a parametric study on the crashworthiness design of composite-to-composite and composite-to-metal joints. GRA

N90-27698# National Aeronautical Establishment, Ottawa (Ontario).

A REVIEW OF RESEARCH AND DEVELOPMENT IN CRASHWORTHINESS OF GENERAL AVIATION AIRCRAFT: SEATS, RESTRAINTS AND FLOOR STRUCTURES

Aeronautical Note

P. HUCULAK Feb. 1990 89 p
(AD-A221557; NAE-AN-64; NRC-31334) Avail: NTIS HC A05/MF A01 CSCL 01/3

A literature search has been conducted to determine the status of knowledge of the crashworthiness aspects of general aviation aircraft. Research and development work relating to seats, restraints, and floor structures of general aviation aircraft was selected for review. The primary goal of crashworthiness studies was the reduction of fatal and serious accidents. Study of the work on seats, restraints, and floor structures has revealed that more attention to several research topics could ameliorate high accident rates in general aviation. GRA

N90-27699*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DEVELOPMENT AND TESTING OF METHODOLOGY FOR EVALUATING THE PERFORMANCE OF MULTI-INPUT/MULTI-OUTPUT DIGITAL CONTROL SYSTEMS

ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA.), CAROL D. WIESEMAN, SHERWOOD TIFFANY HOADLEY, and VIVEK MUKHOPADHYAY Aug. 1990 12 p Presented at the 1990 AIAA Guidance, Navigation, and Control Conference, Portland, OR, 20-22 Aug. 1990 (NASA-TM-102704; NAS 1.15:102704) Avail: NTIS HC A03/MF A01 CSCL 01/3

A Controller Performance Evaluation (CPE) methodology for multi-input/multi-output digital control systems was developed and tested on an aeroelastic wind-tunnel model. Modern signal processing methods were used to implement control laws and to acquire time domain data of the whole system (controller and plant) from which appropriate transfer matrices of the control system could be generated. Matrix computational procedures were used to calculate singular values of return-difference matrices at the plant input and output points to evaluate the performance of the control system. The CPE procedures effectively identified potentially destabilizing controllers and confirmed the satisfactory performance of stabilizing ones. Author

N90-27700*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EFFECTS OF SPOILER SURFACES ON THE AEROELASTIC BEHAVIOR OF A LOW-ASPECT-RATIO RECTANGULAR WING

STANLEY R. COLE Apr. 1990 11 p Previously announced in IAA as A90-29371 (NASA-TM-102622; NAS 1.15:102622) Avail: NTIS HC A03/MF A01 CSCL 01/3

An experimental research study to determine the effectiveness of spoiler surfaces in suppressing flutter onset for a low-aspect-ratio, rectangular wing was conducted in the Langley Transonic Dynamics Tunnel (TDT). The wing model used in this flutter test consisted of a rigid wing mounted to the wind-tunnel wall by a flexible, rectangular beam. The flexible beam was connected to the wing root and cantilever mounted to the wind-tunnel wall. The wing had a 1.5 aspect ratio based on wing semispan and a NACA 64A010 airfoil shape. The spoiler surfaces consisted of thin, rectangular aluminum plates that were vertically mounted to the wing surface. The spoiler surface geometry and location on the wing surface were varied to determine the effects of these parameters on the classical flutter of the wing model. Subsonically, the experiment showed that spoiler surfaces increased the flutter dynamic pressure with each successive increase in spoiler height or width. This subsonic increase in flutter dynamic pressure was approximately 15 percent for the maximum height spoiler configuration and for the maximum width spoiler configuration. At transonic Mach numbers, the flutter dynamic pressure conditions were increased even more substantially than at subsonic Mach numbers for some of the smaller spoiler surfaces. But greater than a certain spoiler size (in terms of either height or width) the spoilers forced a torsional instability in the transonic regime that was highly Mach number dependent. This detrimental torsional instability was found at dynamic pressures well below the expected flutter conditions. Variations in the spanwise location of the spoiler surfaces on the wing showed little effect on flutter. Flutter analysis was conducted for the basic configuration (clean wing with all spoiler surface mass properties included). The analysis correlated well with the clean wing experimental flutter results. Author

N90-28077# National Aeronautical Establishment, Ottawa (Ontario). Structures and Materials Lab.

A TECHNIQUE FOR RAPID INSPECTION OF COMPOSITE AIRCRAFT STRUCTURE FOR IMPACT DAMAGE

JERZY P. KOMOROWSKI, RONALD W. GOULD, and WALTER J. PASTORIUS (Diffracto Ltd., Windsor, Ontario) / In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 10 p May 1990 Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A technique using the Diffracto D-Sight method to locate indentations associated with low energy impact damage is described. In graphite/epoxy specimens good correlation was observed between internal impact damage as shown on ultrasonic C scan images and indentations detected with the D-Sight method. Test specimens are currently mounted on the aircraft to observe the influence of in-service surface degradation on technique resolution. The method has the potential for inexpensive, rapid and objective detection of low energy impact damage over large areas of composite aircraft structure. Application of this method, because of its inherent reliability, could result in the increasing of the design allowable strain levels for some composite components. Included are two examples of possible application of D-Sight to metal aircraft for inspection of cold worked holes and detection of cracks. Author

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-46932#

THE EVOLUTION OF DESIGN/DEVELOPMENT REQUIREMENTS FOR AVIONICS/MISSION EQUIPMENT (MEP) INSERTION

H. F. WOCHHOLZ IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 17 p. refs

An overview of the avionics and mission equipment package (MEP) and associated requirements of the overall conceptual design of rotary wing aircraft is presented. The conceptual design process begins with a formulation that results in an architecture identifying the basic system/subsystem elements, their functional interconnections, redundancies, and data rates. MEP considerations in terms of a generalized implementing organizational structure are discussed. Generalized architectures for present/future rotorcraft are considered, along with the Apache Longbow and PAVE PILLAR programs. R.E.P.

A90-47592#

WINDS ALOFT MEASUREMENT AND AIRSPEED CALIBRATION USING LORAN

WALTER M. HOLLISTER (MIT, Cambridge, MA), VENU G. CHIVUKULA, and BURT A. TOMA IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 143-149. refs (AIAA PAPER 90-3331) Copyright

The winds aloft are typically determined on board an aircraft by measurements of the ground track, airspeed and heading. In the experiments reported here, a novel method using Loran data to determine the airspeed and winds aloft without the direct measurement of either heading or airspeed was demonstrated. To perform the measurement it is only necessary that the airspeed be held constant during turns. The effects of error sources on the measurement are predicted and compared with the results of flight test. Author

A90-47763#

UPDATE 90 - A PROGRESS REPORT ON EVALUATION AND FLIGHT TESTING OF THE SMALL COMMON RLG INS

MICHAEL J. HADFIELD and ALAN J. HASSELBRING (Honeywell, Inc., Military Avionics Div., Saint Petersburg, FL) AIAA, Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990. 10 p. (AIAA PAPER 90-3375) Copyright

Key features of the Small Common Inertial Navigation System (SCINS) models and supporting data are presented with special attention given to a discussion of small common ring laser gyro (RLG) INS. The H-764 SCINS, an example of the smaller, lighter, lower-power generation of RLG INS units designed to meet applications for helicopter and fixed-wing aircraft platforms, is described in detail. The units feature a demonstrated reliability and large production base which offer high availability and low acquisition, life cycle, maintenance and spares costs; a heaterless design and cavity free of scatter-producing multioscillator optics which provide instant-on reaction time from power-on and fully rated performance over the military operational temperature range without the need for temperature control; and consistent performance and extensive lifetime over a wide range of applications. GPS compatibility, systems architecture, hardware and software functions, and various performance test results are presented. L.K.S.

A90-48521

COLLISION ALERT

GUY NORRIS Flight International (ISSN 0015-3710), vol. 138, Aug. 22, 1990, p. 29, 30, 32. Copyright

The FAA requires that TCAS II equipment should scan 28 km in front and 14 km in back each second. Basic hardware for the air-to-air anticollision system utilizes the data-exchange capability of the Mode S airborne ATC transponder, with a computer and display to process range and closure information. Systems call up aural warnings and preventive instructions for collision-avoidance maneuvers. U.S. airlines operating more than 60 aircraft are currently under instructions to install TCAS in 20 percent of the fleet by the end of 1990. The ICAO is waiting to adopt TCAS III

which will offer azimuth maneuver guidance in the same composite fashion as TCAS II. The windshear detection and guidance systems are mandated for operational use by Part 121 transport aircraft in early 1991. R.E.P.

A90-48607

THE NEW LIGHT WEIGHT, HIGH PERFORMANCE RECONNAISSANCE CAMERA KRB 8/24 F

BERND UHL (Carl Zeiss, Oberkochen, Federal Republic of Germany) IN: Airborne reconnaissance XIII; Proceedings of the Meeting, San Diego, CA, Aug. 7-9, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 49-56. Copyright

As sensor payload for the CL-289 drone system, Carl Zeiss developed a new compact reconnaissance camera system. The high performance camera with 143 degree wide angle ground coverage, is a pulse operated sequential frame camera. It features true-angle forward motion compensation across the entire format and direct stereoscopic viewing. Small size and low weight permits easy installation in remotely piloted vehicles, pods and aircraft. Author

A90-48620

APPLICATIONS FOR A SMALL FORMAT AIRBORNE RECORDER

THOMAS W. AUGUSTYN (Nacous, Inc., Chatsworth, CA) IN: Airborne reconnaissance XIII; Proceedings of the Meeting, San Diego, CA, Aug. 7-9, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 256-264. Copyright

As the reconnaissance community transitions from film to near real time electro-optics, one obstacle has been the data rate limitations of complementary hardware. A modern linear array sensor can easily produce more bits of imaging data than data links, recorders or hard copy devices can handle. This problem is compounded by TDI and starting arrays with still higher pixel counts. While array and sensor manufacturers continue to strive for resolution equivalent to film, the manufacturers of the complementary hardware are also addressing the steps necessary for this transition. However, this task is made even more difficult due to volumetric constraints and cost concerns. This paper describes a small format recorder (less than 19 mm) based on Super VHS or S-VHS technology. Rather than being a modified commercial unit, the Super SVCR V-301-A has been designed specifically for the severe environment encountered in airborne applications. Details of the recorder's development are presented, and engineering confidence and environmental testing are also summarized. Current and future growth applications, especially those relating to reconnaissance, are also provided. Author

A90-48883#

NEAR-TERM APPLICATIONS OF KNOWLEDGE BASED SYSTEMS TO COMBAT HELICOPTERS

FREDERICK E. HUBER and FRANK KILMER (IBM Corp., Owego, NY) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 7 p. (AIAA PAPER 90-3301) Copyright

This paper discusses application of real-time knowledge based systems to cockpits of military helicopters. The focus of this paper is on in-flight mission replanning capabilities that can be integrated with avionics systems within the next 2-3 years. This paper is a summary of ongoing Independent Research and Development work at IBM Federal Sector Division, Owego, N.Y. Author

A90-48982

FLIGHT-PATH DISPLAY CAN IMPROVE SAFETY, OPERATIONAL EFFICIENCY

JOHN P. DESMOND and RICHARD C. HANSEN (Flight Dynamics, Inc., Portland, OR) ICAO Journal (ISSN 0018-8778), vol. 45, March 1990, p. 14-18. Copyright

An advanced cockpit head-up display (HUD) guidance system, now in airline revenue service, provides the pilot with precision

guidance to touchdown in low visibility conditions through the display of instantaneous inertial flight path and related symbology. The system is a manually controlled, category IIIa, low visibility landing system which utilizes an inertial platform and other high-quality aircraft sensors to allow precise terminal area operations in both visual and instrument meteorological conditions. The system is comprised of five components: an overhead projection unit, a combiner containing a holographic element, a high integrity computer, a drive electronics unit, and a pilot's control panel. Performance results, simulation and flight testing, and future development of the system are discussed. L.K.S.

A90-48995

UPGRADING THE COCKPIT - A MULTIDISCIPLINARY APPROACH

Aerospace Engineering (ISSN 0736-2536), vol. 10, Sept. 1990, p. 27-29.

Copyright

Researchers at Douglas Aircraft have combined computerized ergonomics models with a multidisciplinary approach to achieve a fully integrated flight deck for a derivative aircraft. Computer modeling and an iterative, interdisciplinary decision making process were employed to modify a contemporary flight deck to incorporate new malfunction displays and controls, display formats, and a flight management system. A computer-aided design and drafting (CADD) system comprising a number of computerized human modeling techniques including the crew station assessment of reach (CAR) program was developed. In CADD the external visual capabilities of the flight crew are represented by a system which converts an azimuthal projection of a hemisphere to a flat surface on the inside of a cone. The CAR program produces a 'randomized' population of human bodies of varying proportions. This application of a wide array of ergonomics tools allowed objective analysis to take the place of the less reliable subjective evaluation of flight crew capabilities that are widely employed in the industry. R.E.P.

A90-49502#

PROVIDING AN INEXPENSIVE GYRO FOR THE NAVIGATION MASS MARKET

ANTHONY LAWRENCE (Northrop Corp., Precision Products Div., Norwood, MA) IN: Institute of Navigation, National Technical Meeting, San Diego, CA, Jan. 23-25, 1990, Proceedings. Washington, DC, Institute of Navigation, 1990, p. 161-166. refs

The microoptic gyro is an all-solid-state passive-ring-resonator laser gyro. It uses a waveguide resonator fabricated in glass by ion-exchange, a GaAlAs diode laser, and a SAW frequency shifter, arranged to operate with servos to maintain the CW and CCW ring resonances. The frequency difference between the CW and CCW resonances is a measure of the rotation rate. The equation for the gyro resolution is given, and some data are presented on prototype gyro performance. The differences between the cost and performance of this gyro and fiber-optic gyros are discussed.

Author

A90-49830#

AN AIRBORNE INSTRUMENT FOR CHARACTERIZING THE 10,000 ELECTROMAGNETIC SIGNALS GENERATED BY ONE LIGHTNING FLASH

JEFFREY S. THAYER, JOSEPH E. NANEVICZ, and G. RICHARD HILBERS (SRI International, Menlo Park, CA) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 48-52. refs

Although many scientists are working to characterize lightning by using ground-based measurement systems, some important parameters are best characterized by airborne measurements. This paper describes a compact, lightweight, airborne instrumentation system suitable for characterizing the multiplicity of electromagnetic pulses radiated by a lightning flash.

Author

N90-27448# Army Avionics Lab., Fort Monmouth, NJ.
HOVER POSITION SENSING SYSTEM

STEPHEN P. AHRENS and JOSEPH MCGOWAN (Intermetrics, Inc., Oceanport, NJ.) /n AGARD, Tactical Applications of Space Systems 8 p May 1990

Copyright Avail: NTIS HC A07/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The U.S. Army Light Helicopter Experimental (LHX) aircraft has a requirement for a Hover Hold System with a desired accuracy of 1 meter RMS for a 3 minute period. AVRADA (Avionics Research and Development Activity) recently completed a demonstration program which indicated that an error of 0.6 meter or less is achievable with the LHX navigation sensor suite. The demonstration program and results are presented.

Author

N90-27618#

Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

PAST, PRESENT AND FUTURE: AIRCRAFT INTEGRATED MONITORING SYSTEMS: AN EVER-DEVELOPING TECHNOLOGY

H. HARDEGEN and W. KOSCHEL (Technische Hochschule, Aachen, Germany, F.R.) /n its Aircraft Integrated Monitoring Systems p 9-31 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The statements, plans and visions of the (Aircraft Integrated Monitoring Systems) AIMS-experts twenty years experience are reviewed. The current state of the AIMS technology and the trends to the future are considered. How the plans in the past meet the reality today is underlined. Various applications achieved in the mean time testify the necessity, importance and the significant use of the AIMS.

ESA

N90-27619# Messerschmitt-Boelkow-Blohm G.m.b.H., Hamburg (Germany, F.R.).

AIRCRAFT CONDITION MONITORING SYSTEM FOR FUTURE AIRBUS AIRCRAFT: NEW CONCEPT FOR PROGRAMMING AND DATA RECORDING

MICHAEL SCHWENKE /n DLR, Aircraft Integrated Monitoring Systems p 33-50 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The main differences and advantages of the Aircraft Condition Monitoring System (ACMS) concept compared with the A320 aircraft integrated data system are described. Progress in the development of high integrated electronic components enables an improved ACMS architecture with additional functions. In conjunction with a personal computer on ground and the Smart ACMS Recorder a flexible tool for data acquisition and evaluation is established. Using the experience from the A310 and A320 the new ACMS enables a comprehensive and versatile aircraft condition monitoring and troubleshooting.

ESA

N90-27620# NATO European Fighter Management Agency, Munich (Germany, F.R.).

THE EFA INTEGRATED MONITORING AND RECORDING SYSTEM: REQUIREMENTS AND CONCEPT FOR IMPLEMENTATION

D. P. M. MCGILL and P. A. BROSS (Eurofighter G.m.b.H., Munich, Germany, F.R.) /n DLR, Aircraft Integrated Monitoring Systems p 51-76 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The Integrated Test System (ITS) for pre-flight, in-flight and post-flight monitoring, testing and recording is presented. The principles, philosophies and guidelines adopted for EFA's ITS and for its Integrated Monitoring and Recording Subsystem (IRMS) are described. The use of data for automated health monitoring, diagnostics and support of accident/incident investigations are covered. Some ideas for carrying the concept on into the aircraft's ground support system are provided.

ESA

**N90-27621# Spectralab, Kilchberg (Switzerland).
MULTICHANNEL ON-BOARD LOAD AND FATIGUE
MONITORING**

H. R. WILMS /in DLR, Aircraft Integrated Monitoring Systems p 77-98 Jan. 1990
Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

An overview of the evolution of load and fatigue monitoring during the last ten years is given. The new concepts and architectures of modern monitoring systems are explained. Particular attention is given to the following: hardware (multichannel, cross channeling), software (multiprocessing, multitasking, real time), and protection against environmental conditions. Some examples of and variations in operational aircraft usage are included. ESA

**N90-27624# British Aerospace Aircraft Group, Brough (England).
PERFORMANCE ASSESSMENT OF MIL-STD-1553B ON THE
AVIONIC SYSTEMS DEMONSTRATOR RIG OF BRITISH
AEROSPACE**

P. A. DUKE /in DLR, Aircraft Integrated Monitoring Systems p 143-161 Jan. 1990
Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The Avionic Systems Demonstrator Rig (ASDR) represents a generic modern avionic system. It includes multiple MIL-STD-1553B data buses, a high degree of system control automation, distributed processing resources and integrated overall system operation. An assessment program was carried out on the completed rig. A quantitative measure of the performance of the overall system is provided. The measurement of data bus loading and time delays is emphasized. The system design and the results obtained from the assessment program are presented. ESA

**N90-27640# Deutsche Forschungsanstalt fuer Luft- und
Raumfahrt, Oberpfaffenhofen (Germany, F.R.). Inst. of
Optoelectronics.
AIRBORNE CO2 DOPPLER LIDAR FOR WIND SHEAR
DETECTION**

F. KOEPP /in its Aircraft Integrated Monitoring Systems p 481-499 Jan. 1990
Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The Doppler lidar method was developed for remote sensing of wind fields and turbulence. Different kinds of wind shear were measured using the ground-based continuous wave CO2 system. Current activities comprise the development of a compact airborne Doppler lidar based on pulsed CO2 lasers. This instrument allows the aircraft pilots to detect dangerous wind shear situations several kilometers before encounter. ESA

N90-27642# National Transportation Safety Board, Washington, DC.

THE NEW US FLIGHT RECORDER REGULATIONS

D. R. GROSSI /in DLR, Aircraft Integrated Monitoring Systems p 529-549 Jan. 1990
Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The European Organization for Civil Aviation Electronics (EUROCAE) prepared draft Minimum Operational Performance Requirements (MOPR) for flight recorders, which is planned to be adopted as a new technical standard. The new U.S. recorder requirements and their relationship to the EUROCAE MOPR are discussed. On March 18, 1987, and July 11, 1988 the U.S. Federal Aviation Administration (FAA) issued a change to flight data and cockpit voice recording requirements. These rule changes were in response to a series of National Transportation Safety Board

recommendations intended to expand and improve requirements. ESA

**N90-27643# Canadian Aviation Safety Board, Ottawa (Ontario).
THE CANADIAN AVIATION SAFETY BOARD'S FLIGHT
RECORDER FACILITY**

MICHAEL R. POOLE /in DLR, Aircraft Integrated Monitoring Systems p 551-566 Jan. 1990
Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

In August of 1988, the Canadian Aviation Safety Board completed a new Flight Data Recorder/Cockpit Voice Recorder (FDR/CVR) facility. The facility utilizes software data recovery techniques as opposed to traditional hardware based systems. The analysis of poor quality data is handled through the extensive software based system. A standard library of mathematical routines is interfaced with the data analysis portion of the system. A three dimensional graphics flight reconstruction system provides a real time animation of flight recorder data. ESA

N90-27701*# California Polytechnic State Univ., San Luis Obispo.

**ECONOMICAL GRAPHICS DISPLAY SYSTEM FOR FLIGHT
SIMULATION AVIONICS Final Report**

1990 58 p
(Contract NAG2-375)
(NASA-CR-186886; NAS 1.26:186886) Avail: NTIS HC A04/MF A01 CSCL 01/4

During the past academic year the focal point of this project has been to enhance the economical flight simulator system by incorporating it into the aero engineering educational environment. To accomplish this goal it was necessary to develop appropriate software modules that provide a foundation for student interaction with the system. In addition experiments had to be developed and tested to determine if they were appropriate for incorporation into the beginning flight simulation course, AERO-41B. For the most part these goals were accomplished. Experiments were developed and evaluated by graduate students. More work needs to be done in this area. The complexity and length of the experiments must be refined to match the programming experience of the target students. It was determined that few undergraduate students are ready to absorb the full extent and complexity of a real-time flight simulation. For this reason the experiments developed are designed to introduce basic computer architectures suitable for simulation, the programming environment and languages, the concept of math modules, evaluation of acquired data, and an introduction to the meaning of real-time. An overview is included of the system environment as it pertains to the students, an example of a flight simulation experiment performed by the students, and a summary of the executive programming modules created by the students to achieve a user-friendly multi-processor system suitable to an aero engineering educational program.

Author

**N90-27702*# National Aeronautics and Space Administration.
Ames Research Center, Moffett Field, CA.**

**SIDESLIP-INDUCED STATIC PRESSURE ERRORS IN
FLIGHT-TEST MEASUREMENTS**

EDWIN K. PARKS, RALPH E. BACH, JR., and DUC TRAN Jun. 1990 11 p Presented at the 8th AIAA Applied Aerodynamics Conference, Portland, OR, 20-22 Aug. 1990
(NASA-TM-102846; A-90229; NAS 1.15:102846) Avail: NTIS HC A03/MF A01 CSCL 01/4

During lateral flight-test maneuvers of a V/STOL research aircraft, large errors in static pressure were observed. An investigation of the data showed a strong correlation of the pressure record with variations in sideslip angle. The sensors for both measurements were located on a standard air-data nose boom. An algorithm based on potential flow over a cylinder that was developed to correct the pressure record for sideslip-induced errors is described. In order to properly apply the correction algorithm, it was necessary to estimate and correct the lag error in the pressure

system. The method developed for estimating pressure lag is based on the coupling of sideslip activity into the static ports and can be used as a standard flight-test procedure. The estimation procedure is discussed and the corrected static-pressure record for a typical lateral maneuver is presented. It is shown that application of the correction algorithm effectively attenuates sideslip-induced errors. Author

N90-27703*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EXPERIMENTAL CHARACTERIZATION OF THE EFFECTS OF PNEUMATIC TUBING ON UNSTEADY PRESSURE MEASUREMENTS

STEPHEN A. WHITMORE, WILLIAM T. LINDSEY (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.), ROBERT E. CURRY, and GLENN B. GILYARD Washington Mar. 1990 31 p (NASA-TM-4171; H-1538; NAS 1.15:4171) Avail: NTIS HC A03/MF A01 CSCL 01/4

Advances in aircraft control system designs have, with increasing frequency, required that air data be used as flight control feedback. This condition requires that these data be measured with accuracy and high fidelity. Most air data information is provided by pneumatic pressure measuring sensors. Typically unsteady pressure data provided by pneumatic sensing systems are distorted at high frequencies. The distortion is a result of the pressure being transmitted to the pressure sensor through a length of connective tubing. The pressure is distorted by frictional damping and wave reflection. As a result, air data provided all-flush, pneumatically sensed air data systems may not meet the frequency response requirements necessary for flight control augmentation. Both lab and flight test were performed at NASA-Ames to investigate the effects of this high frequency distortion in remotely located pressure measurement systems. Good qualitative agreement between lab and flight data are demonstrated. Results from these tests are used to describe the effects of pneumatic distortion in terms of a simple parametric model. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A90-46150
THE TURBOFAN OF TOMORROW

GERALD L. BRINES (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) Mechanical Engineering (ISSN 0025-6501), vol. 112, Aug. 1990, p. 65-67. Copyright

A new advanced ducted engine under development at Pratt and Whitney increases thrust by more than 20 percent and reduces fuel consumption by 12 percent when compared with existing high-technology turbofan engines. An extensive technology program is in progress to demonstrate the key technologies of a geared, variable-pitch, lightweight fan, combined with a thin-lip, slimline nacelle that are necessary to achieve a 10:1 to 20:1 bypass ratio. The ducted engine consists of a conventional turbofan core with an ultrahigh bypass-propulsor, a low spool system that includes the fan, low-pressure compressor, low-pressure turbine, and the gear-driven, variable-pitch fan of the low-pressure spool. To address the problem of community noise, the geared fan concept allows each component of the low spool system to be optimized for both noise and performance. Design and construction of a full-scale demonstrator engine will serve to verify thrust reverse through variable pitch, interaction of the variable-pitch fan and the core engine, full-scale acoustics, and the thrust increase

possibilities of an ultrahigh bypass propulsor on a commercially established core engine. R.E.P.

A90-46488
OPERATION OF A GAS EJECTOR IN THE PULSED REGIME
[O RABOTE GAZOVOGO EZHEKTORA V PUL'SIRUIUSHCHEM REZHIME]

S. I. KRASHENINNIKOV, V. K. LIAKHOV, K. V. MIGALIN, M. M. RUSAKOV, and V. B. RIAPOSOV Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 40-43. In Russian. Copyright

The mechanisms by which velocity pulsations in a gas ejector affect the ejection coefficient were investigated experimentally using cylindrical ejectors with mixers of diameters $D = 15.5, 22, 28.5, 33, 40, 48, \text{ and } 52 \text{ mm}$; length $L = 255 \text{ mm}$; and nozzle diameters $d = 6, 8, 11.5, 14.5, \text{ and } 16 \text{ mm}$. It is found that the superposition of pulsations on an active gas jet may increase the ejection coefficient by 20-300 percent. This effect is believed to be related to the generation and subsequent interaction of large-scale ring vortices in the mixing layer. V.L.

A90-46491
A METHOD FOR THE MATCHING OF STRUCTURAL AND GEOMETRIC PARAMETERS OF THE TURBOCOMPRESSORS OF SMALL GAS TURBINE ENGINES IN COMPUTER-AIDED DESIGN [METOD SOGLASOVANIIA

KONSTRUKTIVNO-GEOMETRICHESKIKH PARAMETROV TURBOKOMPRESSOROV MALORAZMERNYKH GTD V SAPR] V. S. KUZ'MICHEV and I. M. SIVTSOV Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 50-53. In Russian. refs Copyright

A method for matching the structural and geometric parameters of turbocompressors at the design stage is proposed which is invariant to the turbocompressor design scheme. The method allows for state-of-the-art concepts of software development. The relatively small number of equations used, and, correspondingly, the small number of independent variables make it possible to use this method for solving more complex problems of the structural-parametric optimization of small-size turbocompressors during computer-aided design. V.L.

A90-46493
OPTIMAL CHOICE OF MEASURED PARAMETERS DURING THE IDENTIFICATION OF GAS TURBINE ENGINES. II - COMBINED CONFIDENCE REGIONS AND INTERVALS OF THE IDENTIFICATION RESULTS [OPTIMAL'NYI VYBOR IZMERIAEMYKH PARAMETROV PRI IDENTIFIKATSII GTD. II - SOVMESTNYE DOVERITEL'NYE OBLASTI I INTERVALY REZUL'TATOV IDENTIFIKATSII]

S. V. EPIFANOV, D. F. SIMBIRSKII, and S. A. KAPLUN Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 57-62. In Russian. Copyright

A method is proposed for obtaining the combined confidence regions and intervals of the results of parametric identification of gas turbine engines, which are used for selecting the measured parameters and other significant experimental factors. Relationships for the confidence intervals of identification results are obtained which can be used as the limits in minimizing the optimality criterion for the measuring system. The approach proposed here is illustrated by an example. V.L.

A90-46495
CALCULATION OF THE EFFICIENCY OF AN ACTIVE PARTIAL-ADMISSION GAS TURBINE FOR COUNTERPRESSURES VARYING OVER A WIDE RANGE
[OSOBENOSTI RASCHETA KPD AKTIVNOI PARTSIAL'NOI GAZOVOI TURBINY PRI IZMENENII PROTIVODAVLENII V SHIROKOM DIAPAZONE]

B. V. OVSIANNIKOV, S. E. UVAROV, and B. G. KHUDENKO Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 66-70. In Russian. refs Copyright

A mathematical model and a calculation procedure are proposed for determining the efficiency of a partial-admission gas turbine in the case where counterpressures vary over a wide range. The approach proposed here allows for the effect of density on disk losses and also for the effect of the flow angle at the exit section of the nozzle under off-design conditions. It is shown that, as the counterpressure increases significantly, the shock waves enter the post-critical nozzle section, the exit velocity becomes subsonic, and the turbine efficiency is substantially reduced. V.L.

A90-46497

COMPUTER-AIDED DESIGN OF COMPRESSOR ROTOR BLADE RINGS [SISTEMA AVTOMATIZIROVANNOGO PROEKTIROVANIYA LOPATOCHNYKH VENTSOV ROTORA KOMPRESSORA]

B. M. ARONOV and N. D. KASTERINA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 75-79. In Russian. refs
Copyright

A method and an algorithm are proposed for the optimum design of the blade rings of the compressor rotor in general and particular cases. The general design of a computer-aided system for the design of blade rings is presented, and the use of the system for research purposes is discussed. A block diagram of the system is included. V.L.

A90-46504

EFFECT OF THE FLUID LEVEL OF A HYDRAULIC SHOCK ABSORBER ON THE CHARACTERISTICS OF THE GAS SUPPLY SYSTEM [O VLIANII STEPENI ZAPOLNENIIA GIDRODEMPFERA ZHIKOST'IU NA KHARAKTERISTIKI BALLONNOI SISTEMY GAZOPITANIYA]

L. S. VERNOVSKII and B. E. VULIKH Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 94, 95. In Russian.
Copyright

Analytical expressions are derived for evaluating the effect of the shock absorber fluid level on the performance characteristics of the gas supply system. To verify these expressions, tests have been conducted on a gas supply system using nitrogen. The results obtained indicate that the expressions proposed here can be used for calculating the final pressure in the gas supply system tank and analyzing the efficiency of the system. V.L.

A90-46505

OPTIMAL BLADING DENSITY IN AXIAL-FLOW COMPRESSOR STAGES WITH A DEVELOPED THREE-DIMENSIONAL FLOW [OPTIMAL'NAIA GUSTOTA RESHETOK V STUPENIYAKH OSEVOGO KOMPRESSORA S RAZVITOI TREKHMERNOI FORMOI TECHENIYA]

A. D. GRIGA, V. N. KORDIUK, and I. N. IATSENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 95-97. In Russian.
Copyright

An approach to blading classification on the basis of flow structure is proposed which uses the parameter of reduced blade aspect ratio. Regression equations are obtained for determining the optimal blading density, and a comparison is made with experimental data for axial-flow compressor stages with optimal blading density. The agreement between the analytical and experimental data is within 5-10 percent. V.L.

A90-46509

EFFECT OF THE NOZZLE RING VANE HEIGHT ON THE EFFICIENCY OF AXIAL-FLOW FULL-ADMISSION MICROTURBINES [VLIANIE VYSOTY LOPATOK SOPLOVOGO APPARATA NA EKONOMICHNOST' OSEVYKH MIKROTURBIN S POLNYM VPUSKOM]

E. E. PFAIFLE and N. T. TIKHONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 103-105. In Russian.
Copyright

The effect of the vane height of the nozzle ring on the efficiency of a single-stage full-admission axial-flow microturbine was investigated experimentally for vane heights of 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 mm, corresponding to the rotor blade heights of 1.2, 2.2, 3.05, 3.0, 4.6, and 5.4 mm, respectively. A sharp increase in

stage efficiency was observed as the vane height was increased from 0.5 to 2 mm; the increase was particularly pronounced with the change from 0.5-mm to 1.0-mm vanes. The mechanisms responsible for the increase in losses in the case of shorter vanes are examined. V.L.

A90-46539

RELATION BETWEEN FLOW PARAMETERS OF A GAS TURBINE ENGINE AND ROTOR FREQUENCIES [O SVIAZI KOLEBANII PARAMETROV POTOKA V GAZOTURBINNOM DVIGATELE S ROTORNymi CHASTOTAMI]

I. L. PIS'MENNYI TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 62-72. In Russian. refs
Copyright

The paper is concerned with the hypothesis of longitudinal oscillations in a gas/air flow path which are characterized by a phase variable over the cross section and treated as a rotating stall. The dynamic characteristic of the flow path is determined analytically, and an oscillation model is developed for an elementary jet. The results of the analysis are examined in comparison with the available experimental data on the rotating stall. V.L.

A90-46546

AN EXPERIMENTAL STUDY OF A SUPERSONIC GAS EJECTOR [EKSPERIMENTAL'NOE ISSLEDOVANIE SVERKHZVUKOVOGO GAZOVOGO EZHEKTORA]

V. A. MALANICHEV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 119-122. In Russian. refs
Copyright

The operation of a supersonic gas ejector was investigated in the critical regime. For the ejector investigated, expressions are obtained for the ejection coefficient as a function of the full pressure ratio and for the ejector compression ratio as a function of the ejection coefficient. Expressions are also obtained which relate the low-pressure gas velocity and the ratio of the static pressures of the low- and high-pressure gases at the mixing chamber inlet to the full pressure ratio of the mixed gases. The results obtained suggest the existence of a previously unknown mechanism of the critical regime. V.L.

A90-46624

TECHNICAL AND ECONOMIC EFFICIENCY OF AVIATION GAS TURBINE ENGINES IN SERVICE [TEKHNICO-EKONOMICHESKAIA EFEKTIVNOST' AVIATSIONNYKH GTD V EKSPLOATATSII]

IRINA A. NIKONOVA and VIACHESLAV T. SHEPEL' Moscow, Izdatel'stvo Mashinostroenie, 1989, 200 p. In Russian. refs
Copyright

Various aspects of the problem of ensuring the safe and cost-effective operation of aviation gas turbine engines are examined. Efficiency criteria are proposed which allow for reliability, service life, and production and repair costs. Methods are also presented for estimating the life-cycle operation costs of gas turbines, ways of implementing safe operation requirements, and organizational aspects, including the delivery system and demand prediction. V.L.

A90-46650

POWER STRUGGLE

GUY NORRIS Flight International (ISSN 0015-3710), vol. 138, Aug. 7, 1990, p. 22-24.
Copyright

Known facts concerning the largely classified configurations of engines for the USAF Advanced Tactical Fighter under development by both General Electric and Pratt and Whitney are presented, and the technology involved in the demonstration program is analyzed. GE's design includes a variable-bypass-ratio system while P&W has chosen an advanced development of its existing F100. The GE engine is believed to incorporate two variable-area bypass injectors including aerodynamically activated bypass valves and a retractable exhaust-noise suppressor which could prove useful in suppressing infrared and noise emissions. The P&W engine features two-dimensional thrust-vectoring exhaust

nozzles, its previously developed military turboprops and a combination of advanced materials, improved cooling techniques, advanced compression aerodynamics, and Hamilton Standard-developed third-generation full-authority digital engine control. L.K.S.

A90-46871#

JET ENGINES PERFORMANCE DETERIORATION

W. TABAKOFF and A. HAMED (Cincinnati, University, OH) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 603-616. refs
(Contract DAAG29-82-K-0029)

An investigation is performed on a two-stage gas turbine with blunt leading edge blades and on a single-stage axial flow compressor to evaluate the effects of particulates and erosion on performance deterioration. The ingestion of particulate matter such as dust and sand contributes to the deterioration of these turbines both aerodynamically and structurally. Variations in particle concentration across the blade channels induce a change in the properties of the flow of gas, which then alters engine performance during particle ingestion. If the particulates are erosive, impingement of particles on the surface of the blade will cause extensive erosion damage that will lead to structural failure of the blades. Factors related to retention of installed engine performance include development of gas-path clearance control systems, improved clearance seal materials, better coating materials, and improved high temperature materials. R.E.P.

A90-46907#

STUDY OF THE EXPANSION OF HYDROCARBON-OXYGEN PRODUCTS THROUGH SUPERSONIC NOZZLE

M. A. ELKADY, M. M. KEMRY, and M. ABDEL AAL (Al-Azhar University, Cairo, Egypt) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 4. Mansoura, Egypt, Mansoura University, 1990, p. 1407-1419. refs

The expansion of a steady isentropic one-dimensional flow of hydrocarbon-oxygen combustion products through a convergent-divergent nozzle is investigated using three models developed for that purpose: (1) a model assuming a frozen gas mixture composition, (2) a model assuming the equilibrium composition of the gas mixture, and (3) a kinetic model which considers the actual flow process for which the reactions controlling the mixture composition have finite rates. The flow properties and the species concentrations are determined for different equivalence ratios and combustion chamber pressures. The results show that the flow characteristics determined using the three models are almost identical in the convergent part of the nozzle, while significant differences exist in the divergent part of the nozzle. For accurate simulation of a real flow problem, the use of the kinetic model is recommended. I.S.

A90-46933*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THE SELECTION OF CONVERTIBLE ENGINES WITH CURRENT GAS GENERATOR TECHNOLOGY FOR HIGH SPEED ROTORCRAFT

JOSEPH D. EISENBERG (NASA, Lewis Research Center, Cleveland, OH) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 26 p. refs

NASA-Lewis has sponsored two studies to determine the most promising convertible engine concepts for high speed rotorcraft. These studies projected year 2000 convertible technology limited to present gas generator technology. Propulsion systems for utilization on aircraft needing thrust only during cruise and those aircraft needing both power and thrust at cruise were investigated. Mission calculations for the two contractors involved were based upon the fold tilt rotor concept. Analysis and comparison of the General Electric concepts (geared UDF, clutched fan, and VIGV fan), and the Allison Gas Turbine concepts (clutched fan, VIGV

fan, variable pitch fan, single rotation tractor propfan, and counter rotation tractor propfan) are presented. R.E.P.

A90-47210*# General Motors Corp., Indianapolis, IN. COMPOSITE MATRIX COOLING SCHEME FOR SMALL GAS TURBINE COMBUSTORS

MARC D. PASKIN, PHILLIP T. ROSS, HUKAM C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and WALDO A. ACOSTA (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990, 11 p. refs

(AIAA PAPER 90-2158) Copyright

The design, manufacture, and testing of a compliant metal/ceramic (CMC) wall cooling concept implementing combustor for small gas turbine engines has been undertaken by a joint U.S. Army/NASA technology development program. CMC in principle promises greater wall cooling effectiveness than conventional designs and materials, thereby facilitating a substantial reduction in combustor cooling air requirements and furnishing greater airflow for the control of burner outlet temperature patterns as well as improving thermodynamic efficiency and reducing pollutant emissions and smoke levels. Rig test results have confirmed the projected benefits of the CMC concept at combustor outlet temperatures of the order of 2460 F, at which approximately 80 percent less cooling air than conventionally required was being employed by the CMC combustor. O.C.

A90-47218*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NASA'S HITEMP PROGRAM FOR UHBR ENGINES

JOSEPH R. STEPHENS (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990, 10 p.

(AIAA PAPER 90-2395) Copyright

NASA's High Temperature Engine Materials Program (HITEMP) is concerned with the laboratory-scale technology development and feasibility demonstration of high-temperature composite materials, in conjunction with the requisite structural analysis models and test methods for their validation. HITEMP encompasses research on metallic/intermetallic, ceramic, and polymer matrix composites, and is giving attention to high-temperature component composites applicable to future widebody commercial aircraft ultrahigh bypass ratio (UHBR) engines. The UHBR components for which advanced composites are envisioned are fan, compressor, and turbine rotor blades, stator vanes, disks, and shafts, thrust bearings, gearbox bearings and linings, combustor cases and linings, nacelles, and thrust-reversers. O.C.

A90-47219*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMBUSTOR TECHNOLOGY FOR FUTURE AIRCRAFT

ROBERT R. TACINA (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990, 31 p. refs

(AIAA PAPER 90-2400) Copyright

The continuing improvement of aircraft gas turbine engine operating efficiencies involves increases in overall engine pressure ratio increases that will result in combustor inlet pressure and temperature increases, greater combustion temperature rises, and higher combustor exit temperatures. These conditions entail the development of fuel injectors generating uniform circumferential and radial temperature patterns, as well as combustor liner configurations and materials capable of withstanding increased thermal radiation even as the amount of cooling air is reduced. Low NO(x)-emitting combustor concepts are required which will employ staged combustion. The development status of component technologies answering these requirements are presently evaluated. O.C.

A90-48529

FAULT-TOLERANT TRANSPUTER-BASED CONTROLLER CONFIGURATIONS FOR GAS-TURBINE ENGINES

H. A. THOMPSON and P. J. FLEMING (North Wales, University College, Bangor, Wales) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 137, pt. D, no. 4, July 1990, p. 253-260. Research supported by SERC and Rolls-Royce, PLC.

Copyright

A project investigating the use of transputers in gas-turbine engine control is described and an effort is made to produce a fault-tolerant high-integrity computer module for gas-turbine engine control. The characteristics of faults are identified for operational and design faults, and fault-tolerant techniques, which chiefly rely on redundancy, are described for both hardware and software. Design constraints of aircraft engines are discussed, and a design philosophy and method for overlapping triads are presented. The overlapping triad configuration implements operational fault tolerance within the constraints imposed by the design philosophy, which addresses operational fault tolerance within the confines of transputer communication restrictions and power plant controller constraints. Particular features of this scheme are methodologically explored and the realization of this configuration in hardware is discussed.

L.K.S.

A90-48871* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THERMAL MANAGEMENT FOR A MACH 5 CRUISE AIRCRAFT USING ENDOTHERMIC FUEL

DENNIS H. PETLEY (NASA, Langley Research Center, Hampton, VA) and STUART C. JONES (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. refs

(AIAA PAPER 90-3284) Copyright

The present thermal management system for a carrier-based Mach 5 cruise-capable aircraft whose propulsion system does not entail cryogenic fuels is predicated on the use of the catalytic endothermic reaction of a petroleum-derived hydrocarbon fuel as the heat sink for engine cooling. The insulation of engine flowpath surfaces reduces cooling requirements. The primary elements of this closed-cycle cooling system are a fuel preheater, a catalytic fuel reactor, and engine wall-cooling panels; a silicone-based liquid polymer is used as the coolant. Structural, weight, and thermal analysis results are presented for each of the primary components.

O.C.

A90-48872*

BENEFITS OF ADVANCED MATERIALS, STRUCTURES, AND AERODYNAMICS IN FUTURE HIGH SPEED CIVIL TRANSPORT PROPULSION SYSTEMS

G. E. ALLEN, G. CHAMPAGNE, H. L. KLEIN, and R. M. ADLER (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 9 p. refs

(AIAA PAPER 90-3285) Copyright

Recent studies conducted under the NASA sponsored High Speed Civil Transport (HSCT) program have indicated that a significant market opportunity exists for a 2nd generation supersonic commercial transport by the early 21st century. The aircraft must be economically competitive with a subsonic transport fleet and meet stringent environmental constraints, particularly in relation to community noise and nitrous oxide emissions. The propulsion system represents a critical element in achieving an economically affordable, environmentally acceptable High Speed Civil Transport. This paper identifies key propulsion system material, structural, and aerodynamic technologies required for an integrated HSCT aircraft/propulsion system designed for a 5000 nautical mile Mach 3.2 cruise. The benefits of these key technologies are also presented in terms of aircraft takeoff gross weight, fuel consumption, and cruise NOx emissions.

Author

A90-48874*

PROPULSION SYSTEM FLIGHT TEST ANALYSIS USING MODELING TECHNIQUES

S. J. KHALID (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL) and M. F. FAHERTY (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 14 p. refs

(Contract F33657-84-C-2014)

(AIAA PAPER 90-3288) Copyright

The utilization of analytical tools in emulating the in-flight performance and operation of a fighter engine that is designed to meet stringent operational requirements is described. In order to ensure an expeditious envelope expansion and to plan applicable maneuvers, pre-flight model predictions are developed. Flight test data driven engine models for post-flight analysis provide calculated values of hard-to-measure parameters. The complete checkout of every control logic path, including all the failure mode accommodations, shows the reliability of the system, therefore increasing the confidence in the success of the flight test program. Comparative results between performance synthesis and flight test data are provided.

R.E.P.

A90-48881*

PROPULSION SYSTEMS FOR VERTICAL FLIGHT AIRCRAFT

A. BROOKS (GE Aircraft Engines, Lynn, MA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p. refs

(AIAA PAPER 90-3299) Copyright

The present evaluation of VTOL airframe/powerplant integration configurations combining high forward flight speed with safe and efficient vertical flight identifies six configurations that can be matched with one of three powerplant types: turboshafts, convertible-driveshaft lift fans, and gas-drive lift fans. The airframes configurations are (1) tilt-rotor, (2) folded tilt-rotor, (3) tilt-wing, (4) rotor wing/disk wing, (5) lift fan, and (6) variable-diameter rotor. Attention is given to the lift-fan VTOL configuration. The evaluation of these configurations has been conducted by both a joint NASA/DARPA program and the NASA High Speed Rotorcraft program.

O.C.

A90-49451

UNSTEADY AERODYNAMICS AND AEROELASTICITY OF TURBOMACHINES AND PROPELLERS; PROCEEDINGS OF THE FIFTH INTERNATIONAL SYMPOSIUM, BEIJING, PEOPLE'S REPUBLIC OF CHINA, SEPT. 18-21, 1989

TIANMIN PAN, ED., YINGJIE LU, ED., WENXUAN YAN, ED., and XIAOLU WU, ED. Symposium organized by Beijing University of Aeronautics and Astronautics. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, 525 p. For individual items see A90-49452 to A90-49476, A90-49478 to A90-49488.

Copyright

The present conference discusses a novel method for high speed propeller flutter prediction, blade loads due to unsteady flow in turbomachine cascades, the flow field around an oscillating cascade, axial flow compressor response to inlet periodic dynamic distortion, dynamic breaking in the compressor stall/surge limit, a numerical solution of the two-dimensional transonic flow through an axial turbine stage, the interaction between vibrating cascade blades and shear flow, and the rotating stall of centrifugal compressors. Also discussed are the effects of blade mistuning and coupled disk-blade on cascade flutter boundaries, cavity resonance in an aircraft engine casing during rig testing, noise generation by swept cascades, an advanced Pelton steam turbine rotor design with waste heat recovery, and aerodynamic losses in conventional high bypass ratio turbofan blades.

O.C.

A90-49453

MEAN LOADING EFFECTS ON FLUTTER OF SUBSONIC ROTATING ANNULAR CASCADE

MASANOBU NAMBA, KAZUHIKO TOSHIMITSU, and PING LI (Kyushu University, Fukuoka, Japan) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New

York, International Academic Publishers/Pergamon Press, 1990, p. 21-31.

Copyright

A three-dimensional theory for unsteady subsonic annular cascade of blades oscillating with nonzero steady loading is developed. The model adopted in this theory is an isolated rotor with N vibrating blades rotating at a constant angular velocity in an infinitely long annular duct. Extensive parametric studies of the effects of the mean angle of attack, camber, and thickness upon the unsteady aerodynamic forces and the flutter boundaries have been conducted. Numerical results of the present three-dimensional theory are compared with the results of the strip theory approximation to demonstrate some features of three-dimensional effects. It is found that the three-dimensional effect is essentially important.

Author

A90-49454

A NEW METHOD FOR HIGH SPEED PROPELLER FLUTTER PREDICTION

QIUSHENG LIU, MENGJU SHEN, and QIONG ZHANG (Tsinghua University, Beijing, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 32-42. refs

Copyright

A new method with a Similar-Plane-Cascade Model (SPCM) for predicting propeller flutter is proposed. The unsteady flow field between two adjacent oscillating blades is divided into a steady mean field and an unsteady small perturbation one. An efficient numerical method developed by the authors is applied to simulate the steady mean flow field. With an assumption of harmonic time dependence, the perturbation potential equation governing the unsteady flow is reduced to a simple potential amplitude equation. After that, it is solved efficiently by use of the line relaxation iteration method in von Mises coordinate system. The propeller flutter is studied by means of the 'energy method'. Predictions have been performed on two propellers. The results agree well with available flight tests and show that the modified Sisto model is applicable to transonic cascade flows. The present method is advantageous in its mathematical simplicity and fast convergence rate. It brings about significant savings in CPU time while providing satisfactory accuracy.

Author

A90-49466

THE INTERACTION BETWEEN DISTORTION OF INLET FLOW AND BLADE STALL FLUTTER IN AXIAL-FLOW COMPRESSOR

X. D. YANG and YU CHENG FENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 167-177. refs

Copyright

The distortion of inlet flow has a significant effect on the performance of an axial-flow compressor or fan. Testing of blade stall flutter on an axial-flow compressor is studied. The test rotor encounters the stall flutter when the inlet flow is uniform. The test shows that stall flutter disappears when inlet flow is distorted. In order to study this phenomenon a numerical actuator disk method, which can predict three-dimensional unsteady flow in axial flow compressors, is developed. The strip theory and numerical actuator disk method are used to predict stall flutter in the inlet flow distortion. The computation indicates that the numerical actuator disk method is effective for the stall flutter in the flow distortion. It is shown that suitable inlet flow distortion can dispel the stall flutter in turbomachinery.

Author

A90-49470

SOME EXPLORATIONS ON THE MECHANISM OF BLADE FLUTTER SUPPRESSION BY POROUS WALL CASING

RONG-GUO CHEN, XING-LU WEI, and SHENG ZHOU (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 213-220. refs

Copyright

The present consideration of the technique of turbomachine blade flutter suppression by means of a porous wall casing uses a model of flow around a two-dimensional plane cascade in which the spanwise unsteady disturbance velocity component is taken into account. The numerical results obtained indicate that the porous wall casing could have a significant influence on blade row aeroelastic stability. The relations between the geometric parameters of a porous wall casing and the aeroelastic stability of a blade row are noted to be complex, so that blade-row aeroelastic stability will deteriorate if the porous wall's acoustic impedance values are poorly selected.

O.C.

A90-49482

AEROELASTIC VIBRATIONS OF TURBOMACHINE BLADES AND PROPELLERS

IU. S. VOROB'EV and M. L. KORSUNSKII (AN USSR, Institut Problem Mashinostroeniia, Kharkov, Ukrainian SSR) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 382-389.

Copyright

Turbomachine blade system vibrations are studied with attention given to the interaction of blades through the flow and elastic bonds. Consideration is given to the applicability of different mathematical models. The role of inertial and deformation connections between different vibration modes is discussed.

K.K.

A90-49487

AERODYNAMIC LOSSES IN CONVENTIONAL FAN BLADES OF HIGH BY PASS TURBO ENGINE

SOHAIL MAHMOOD (Pakistan International Airlines Corp., Training Centre, Karachi) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 497-502.

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Existing conventional fan blades of high bypass turbofan engines have different aerodynamic losses, namely secondary loss, shock loss, profile loss, clapper loss, and losses due to blade boundary layer separation. These losses can be minimized by adopting optimized tip geometry, supercritical airfoil, reduced blade diffusion rate, snubberless design, wide chord and improved diffusion through the blade root. By minimizing the above described losses fan efficiency can be improved. This results in an increase of thrust, hence reduction in specific fuel consumption.

Author

N90-26831# Ohio State Univ., Columbus. Dept. of Mechanical Engineering.

A HEAT TRANSFER ANALYSIS FOR ROUGH TURBINE AIRFOILS Final Report, Apr. 1986 - Mar. 1989

LIT S. HAN and MAJID DELPASSAND 16 Jan. 1990 83 p (Contract F33615-86-K-2621; AF PROJ. 3066) (AD-A221942; AFOSR-89-2135TR) Avail: NTIS HC A05/MF A01 CSCL 21/5

In this research program, a methodology has been developed to calculate the increased heat transfer to turbine airfoils with surface roughness. The new model is adaptable to methods of finite-difference calculation, as opposed to correlation relations currently in use. The model utilizes an amplification factor for the thermal mixing length which is dependent on the local roughness height and surface shear stress.

GRA

N90-26832# Aeronautical Research Labs., Melbourne (Australia). Propulsion Div.

COMPARATIVE EVALUATION OF ALLISON T56 ENGINE CHIP DETECTORS

P. J. GAGE Sep. 1989 25 p

(AD-A221864; ARL-PROP-TM-469; DODA-AR-006-054) Avail: NTIS HC A03/MF A01 CSCL 17/6

Several new chip detectors were compared with types presently in use in the Allison T56 engine. The detectors were ranked according to the mass of debris collected in a set period. The tests indicated that two of the new plugs gave satisfactory performance, and hence could be used as replacements for current types. Two of the new plugs gave lower performance than existing plugs. GEA

N90-26898# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MODELING OF SUPERSONIC REACTING FLOW FIELDS

J. P. DRUMMOND and H. S. MUKUNDA /in Sandia National Labs., Summary of Discussions at the Eleventh Meeting of the Sandia Cooperative Group on the Aerothermochemistry of Turbulent Combustion p 10-20 Oct. 1988

Avail: NTIS HC A03/MF A01 CSCL 21/5

A detailed understanding of the scramjet combustor flow field is critical to the achievement of a successful design. Even though the combustor flow field is quite complex, it can be realistically viewed as a collection of spatially developing and reacting supersonic mixing layers that are initially discrete, but that ultimately merge into larger more complex zones. These mixing layers begin downstream of a set of fuel injectors that introduce gaseous hydrogen in both a parallel and transverse direction into a supersonic air stream entering from the engine inlet. The behavior of the initial portion of the combustor flow, in the mixing layers near the fuel injectors, appears to be most critical, since this is where the mechanism for efficient high speed mixing must be established to achieve the required degree of combustion downstream. Because of the structure of the flow field in this initial portion of the combustor, a single supersonic, spatially developing and reacting mixing layer serves as an excellent physical model for the overall flow field. Even though this reacting mixing layer flow is geometrically simple, it can still be made to retain all of the fluid mechanical and chemical complexities present in the actual combustor flow field. Author

N90-27626# National Technical Univ., Athens (Greece).

COMPUTER MODELING AND DATA PROCESSING METHODS: AN ESSENTIAL PART OF JET ENGINE CONDITION MONITORING AND FAULT DIAGNOSIS

K. MATHIOUDAKIS, A. STAMATIS, E. LOUKIS, and K. PAPAILIOU /in DLR, Aircraft Integrated Monitoring Systems p 185-213 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Methods of processing measurement data in order to derive information about the health of an engine are presented. Both aerothermodynamic performance and fast response measurement data are covered. The principles and results of an advanced gas path analysis method are given. The method of adaptive performance modeling and its application to fault diagnosis is described. Identification of faults on rotating blades by using unsteady pressure measurements is discussed. Extraction of diagnostic information from casing acceleration acoustic measurements is studied. ESA

N90-27627# Technische Univ., Munich (Germany, F.R.). Inst. fuer Luft- und Raumfahrt.

EXPERIMENTAL IDENTIFICATION OF HELICOPTER ENGINE DYNAMICS FROM CLOSED LOOP DATA

M. MENRATH, W. ERHARD, and G. KAPPLER /in DLR, Aircraft Integrated Monitoring Systems p 215-240 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60

58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Due to the complex mission profiles of modern helicopter gas turbines, engine condition monitoring requires a high accuracy dynamic engine model. The identification of the dynamic engine model with the real engine operation condition has to be established on the basis of experimental modeling. The dynamic behavior of the engine can be described for small disturbances by a low order state space model. A maximum likelihood procedure was used for system identification of an Allison 250-C20B gas turbine in a closed control loop. The measurement systems were investigated. For the supply of real engine data a fully computerized helicopter gas turbine test stand was built. ESA

N90-27631# Universitaet der Bundeswehr, Hamburg (Germany, F.R.). Inst. fuer Automatisierungstechnik.

KNOWLEDGE BASED DIAGNOSIS OF JET ENGINES UNDER CONSIDERATION OF MODEL BASED METHODS

U. WILLAN and R. LUNDERSTAEDT /in DLR, Aircraft Integrated Monitoring Systems p 293-318 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

An introduction and overview on knowledge based procedures operating with an expert system are given. Model based procedures on the basis of a gas-path-analysis are integrated in the expert system. Its performance and range of usage are improved and fault free measurement data are to be guaranteed. Algorithms derived eliminate both stochastic and systematic measurement errors. The general considerations are applied on the engine RB 199 of the Tornado jet fighter. Several diagnosis results are pointed out. ESA

N90-27704# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

AGARD/SMP REVIEW DAMAGE TOLERANCE FOR ENGINE STRUCTURES. 3: COMPONENT BEHAVIOUR AND LIFE MANAGEMENT

Jun. 1990 71 p In ENGLISH and FRENCH Meeting held in Ottawa, Ontario, 23-28 Apr. 1989 Original contains color illustrations

(AGARD-R-770; ISBN-92-835-0545-X) Copyright Avail: NTIS HC A04/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Current approaches to the prediction of component behavior and the establishment of suitable inspection schedules were surveyed. The role of testing and life management planning in these approaches was examined. Future technology requirements and the need for a common AGARD approach were discussed.

N90-27705# Rolls-Royce Ltd., Derby (England). Materials and Mechanical Technology.

AGARD DAMAGE TOLERANCE CONCEPTS FOR ENGINE STRUCTURES WORKSHOP 3, COMPONENT BEHAVIOUR AND LIFE MANAGEMENT

R. H. JEAL /in AGARD, AGARD/SMP Review Damage Tolerance for Engine Structures. 3: Component Behaviour and Life Management 9 p Jun. 1990 Original contains color illustrations

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This workshop covered the critical technologies that relate the science of materials and defect behavior, and the knowledge of component quality, to the reality of component performance in the engine. The initial predictions of life and integrity, even using today's complex models and super computing methodology, is relatively cheap. The validation of these models by component testing and engine accelerated mission testing is expensive. The inevitable move to less validation testing must be balanced by appropriate in service planning and monitoring. This workshop

should allow balance of these to be assessed at today's level of capability. Author

N90-27709# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec). Structures and Dynamics.

LIFE MANAGEMENT PLANNING

K. REZAI and R. N. TADROS In AGARD, AGARD/SMP Review Damage Tolerance for Engine Structures. 3: Component Behaviour and Life Management 6 p Jun. 1990

Copyright Avail: NTIS HC A04/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Structural integrity and safe operation of gas turbine engines for commercial aircraft was gained through the application of a life management procedure, which combines state of the art technology from various disciplines of engineering. The core of the process is substantiation of components and their materials for low cycle fatigue/mission life and it is essentially based on Safe Life Approach (SLA) design. Fracture mechanics analyses are also applied in some cases for proper understanding of the behavior of materials susceptible to fatigue crack growth. The life management procedure is discussed. Basic lifing process on the basis of SLA and application of fracture mechanics are also presented. Author

N90-27710# Royal Aircraft Establishment, Farnborough (England). Propulsion Dept.

COMPONENT BEHAVIOUR AND LIFE MANAGEMENT: THE NEED FOR COMMON AGARD APPROACHES AND ACTIONS

C. R. GOSTELOW In AGARD, AGARD/SMP Review Damage Tolerance for Engine Structures. 3: Component Behaviour and Life Management 4 p Jun. 1990

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Component behavior and life management are central to Damage Tolerant Design and Engine Certification. With an 'international product' such as the gas turbine engine there is a need for labs in the various countries to be able to believe each others data, results, and fly modern engines using new lifing methods, materials, and manufacturing processes with confidence and in safety. In particular; all AGARD Countries are customers and users of gas turbine engines, military and civil, bought from a number of sources. There is a need to establish a common position if components lifed by DTD are to be introduced and managed in a safe and cost effective manner, and the various Lifing Authorities convinced that the lifing methodologies are safe. There are a number of material related areas that would benefit from collaborative activity: Materials (small cracks, mission cycling, surface condition, and statistics); Stress Analysis (algorithms, and forging modeling); and damage rules. Author

N90-27711# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.

COMPARATIVE ENGINE PERFORMANCE MEASUREMENTS

May 1990 289 p Lecture series held in Torino, Italy, 14-15 May 1990; in London, England, 17-18 May 1990; in Montreal, Quebec, 4-5 Jun. 1990; and in Monterey, CA, 7-8 Jun. 1990

(AGARD-LS-169; ISBN-92-835-0565-4) Copyright Avail: NTIS HC A13/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The AGARD Propulsion and Energetics Panel has sponsored an international, interfacility comparison program for turbine test facilities over the past nine years. The effort was driven by the critical nature of engine test measurements and their influence on aircraft performance predictions, as well as the need for a sound understanding of test-related factors which may influence measurements. The basic idea was that a nominated engine would be tested in several facilities, both ground-level and altitude, the results then compared, and explanations sought for any observed differences. The information obtained from this comprehensive

program is presented. Emphasis is given to the definition and explanation of differences in test facility measurements and to the lesson learned from this experiment.

N90-27712# Sverdrup Technology, Inc., Arnold AFS, TN.

DESIGN OF THE UETP EXPERIMENT

ROBERT E. SMITH, JR. In AGARD, Comparative Engine Performance Measurements 10 p May 1990

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An experiment was successfully designed to meet the objectives of the Uniform Engine Test Program (UETP) as defined by the Propulsion and Energetics Panel (PEP) of AGARD. The experiment was based on the use of two specially modified J57-PW-19W turbine engines. The experiment was compatible with the capability and availability of eight different engine test facilities located within five NATO countries. Four of these test facilities are ground-level engine test facilities, and four are altitude engine test facilities. The experiment as designed was consistent with the test resources available at each test site. The design of the experiment included the specification of the test article, the matrix of variables, the experimental measurements, and the formats of the test reports. In addition, the design of the experiment included the definition of three methodologies, i.e., test, data processing, and measurement uncertainty, to the minimum extent necessary to meet the objectives of the UETP, and to maximize the level of confidence in the comparative engine performance measurements from each facility. This approach was consistent with a basic requirement of the UETP, which was to utilize local facility practices to the maximum extent possible. The experiment as designed was defined in a General Test Plan which was coordinated with and approved by all participants in the Uniform Engine Test Program. The General Test Plan was published and made available to all program participants. A literature search did not identify any existing publications which defined experiments of the scope required for the UETP. The successful design of the UETP experiment was a major technical and management accomplishment and was a key contributor to the success of the UETP. The General Test Plan should serve as a baseline for the design of future experiments having the scope and complexity of the AGARD Uniform Engine Test Program. Author

N90-27713# Royal Aerospace Establishment, Farnborough (England). Dept. of Propulsion.

THE BASIS FOR FACILITY COMPARISON

A. R. OSBORN In AGARD, Comparative Engine Performance Measurements 28 p May 1990

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One of the main objectives of the Uniform Engine Test Program (UETP) was an engine facility comparison to identify the bias measurement performance differences between the sites. The methods used to present these comparisons are identified and the alternative presentations considered in the Working Group 15 discussions, but not published elsewhere. In addition, many other factors affecting engine performance determination are discussed and the planned methodology adopted by the UETP to determine these elemental differences. Finally, some examples of UETP engine performance measurement anomalies are highlighted and an attempt made to identify the reason for them with a recommendation on how they should be treated. Author

N90-27715# Sverdrup Technology, Inc., Arnold AFS, TN.

COMPARISON OF ALTITUDE TEST CELL RESULTS

ROBERT E. SMITH, JR. In AGARD, Comparative Engine Performance Measurements 12 p May 1990

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The steady-state performance of the J57-PW-19W engine as measured in four altitude test facilities located at NASA (Lewis),

AEDC, RAE(P), and CEPr was compared and analyzed at each of ten simulated flight conditions. All of the performance comparisons were based on six pairs of fundamentally related parameters, which included combinations of engine rotor speeds, temperature ratio, pressure ratio, airflow, fuel flow, net thrust, and specific fuel consumption. Two different methods were used to make the facility comparisons. First, the facility performance was compared using all engine data over the full range of test conditions and power settings tested. The comparison between the four altitude facilities was based on the fraction of test data which are within a 2-percent band i.e., + or - 1 percent of the mean performance curves at each of the ten environmental test conditions. Second, facility performance was compared using the overall percentage spread of the characteristic curves fit to the six pairs of key engine performance parameters for all of the simulated flight conditions at one engine power setting. Facility comparisons based on the first method showed approximately 90 percent or more of all the data was within a 2-percent bandwidth for four of the six parameter sets, i.e., engine speed ratio, engine temperature ratio, airflow, and specific fuel consumption. Only about 65 percent of the fuel flow and net thrust data was within the 2-percent band. The fuel flow and thrust data from Centre d'Essais des Propulseurs (CEPr) were significantly different from the other three test facilities and combined confirmed anomalies. Omitting the CEPr data for these two parameters increased the fraction of data points within the 2-percent band to 85 percent for fuel flow and 92 percent for net thrust. The ranges of overall engine performance spreads based on the second method are presented for three of the key pairs of engine performance parameters. The differences were evaluated at approximately the mid-thrust level of the engine power range at each of the test conditions. Author

N90-27716# National Research Council of Canada, Ottawa (Ontario). Engine Lab.

COMPARISON OF GROUND-LEVEL TEST CELLS AND GROUND-LEVEL TO ALTITUDE TEST CELLS

D. M. RUDNITSKI / In AGARD, Comparative Engine Performance Measurements 13 p May 1990

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The Uniform Engine Test Program was set up to examine gas turbine test procedures, instrumentation techniques and data reduction methods employed by engine test facilities in several AGARD countries. Two major classes of facilities participated, altitude and ground-level test beds. Two engines were to be operated in the test facilities, but as the program evolved, only one engine was tested in all the altitude facilities, and the other in the ground-level beds, with some overlap between. Thus the performance assessment had to be laid out with three specific objectives: altitude with altitude; ground-level with ground-level; and ground-level with altitude. This lecture will deal with ground-level with ground-level and ground-level with altitude. Steady-state performance of a J57-P-19 turbojet engine was evaluated in four ground-level test beds, three of them enclosed: NRCC, CEPr, and TUAf, and an open-air test bed at NAPC. Detailed inter-facility comparisons were made on the three basic engine parameters, airflow, net thrust, and specific fuel consumption, and reasons sought for any differences. The ground-level with altitude objective was to compare data taken in an altitude facility to those obtained in a ground-level test bed. As not all facilities tested both engines in the round-robin, engine SN 607594 was used for altitude to altitude and altitude to ground-level, and engine 615037 for ground-level bed comparison. AEDC was the only altitude facility capable of operation at sea-level-static conditions for both engines, which provided a direct comparison of the validity of the normalizing equations. CEPr tested one engine in both a ground-level bed and in their altitude facility. Significant data scatter and biases in the CEPr data made meaningful comparisons of dubious value, reducing the size of the database. Author

N90-27718# Sverdrup Technology, Inc., Arnold AFS, TN.
EXPERIENCE IN DEVELOPING AN IMPROVED DESIGN OF EXPERIMENT (LESSONS LEARNED)

ROBERT E. SMITH, JR. / In AGARD, Comparative Engine Performance Measurements 5 p May 1990

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The design of the experiment for the AGARD PEP Uniform Engine Test Program (UETP) was a highly successful effort. The plan and organization for this program included contemporary recording of lessons learned regarding improvements to the design of the UETP experiment. Nine major lessons learned were identified which provide the opportunity for improvements in the design of experiments for future programs having a scope and complexity similar to the UETP. These lessons learned were spread across the seven key technical elements of the experiments as follows: test article - validated engine math model; matrix of variables - engine performance tracking; experimental measurements - referee tailpipe measurements, engine inlet turbulence; test method - compressor inlet flow distortion engine thermal stabilization; test data processing - lapse characteristics for engine performance; measurement uncertainty - defined measurement process; and reporting - data comparison strategies. In addition, one lesson learned related to the management of major, round-robin programs. Author

N90-27719# Royal Aerospace Establishment, Farnborough (England). Dept. of Propulsion.

EXPERIENCE IN DEVELOPING AN IMPROVED ALTITUDE TEST CAPABILITY

A. R. OSBORN / In AGARD, Comparative Engine Performance Measurements 16 p May 1990

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Each test site benefitted in different ways from participating in the Uniform Engine Test Program (UETP), not least from observing how other test sites approached the testing, through participating in the Working Group discussions on procedures and methods of analysis. A review of the lessons learned by the participants during the altitude testing of the UETP was carried out and a strategy proposed for an improved altitude test capability. Many of the good practices proposed for a better test capability are based on experience found to be successful at RAE, Pyestock, in the UK. Author

N90-27721# Sverdrup Technology, Inc., Arnold AFS, TN.

GENERAL TEST PLAN

ROBERT E. SMITH, JR. / In AGARD, Comparative Engine Performance Measurements 139 p May 1990 Revised

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The overall purpose of the AGARD-Uniform Engine Test Program (UETP) is to bring an understanding of turbine ground test data for participating AGARD countries to a common denominator, and to improve test techniques, instrumentation and test equipment for turbine engine testing. The improved understanding and methods are to be achieved through a comparative engine test program. Two J57P-19W nonafterburning turbojet engines are to be made available from the U.S. Air Force. The plug type nozzle of the J57 will be replaced with a cylindrical tailpipe and a reference convergent nozzle. The intent of replacing the exhaust nozzle is to simplify the installation of nozzle instrumentation and the calculation of nozzle performance. Certain fixed instrumentation will be provided to travel with the engine. This reference instrumentation will be used to set test conditions, monitor engine health and engine performance degradation. The basic objectives of the UETP is that each participant use those facility test procedures, instrumentation arrangements and analysis methods that are that are consistent with their normal practices to define three basic engine performance parameters: airflow rate

net thrust, and specific fuel consumption. NASA Lewis Research Center will initiate the test program and be responsible for the initial program management. Two newly overhauled engines will be delivered to NASA Lewis Research Center for modification and checkout prior to the initiation of the UETP. The initial and final participant facility tests of the UETP will be conducted at NASA Lewis Research Center. Test data from the final retest at NASA Lewis Research Center will be used to assess engine performance degradation. The purpose of this document, the General Test Plan (GTP), is to specify participant common test hardware, instrumentation, data acquisition, data processing procedures and will serve both as a guideline for the preparation of the participants test plan and as a control document for the identification of the test engine and related test hardware.

Author

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COMPUTER CODE FOR PREDICTING COOLANT FLOW AND HEAT TRANSFER IN TURBOMACHINERY

PETER L. MEITNER Washington Sep. 1990 41 p Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH

(Contract DA PROJ. 1L1-61102-AH-45)

(NASA-TP-2985; E-5186; NAS 1.60:2985; AVSCOM-TR-89-C-008)

Avail: NTIS HC A03/MF A01 CSDL 21/5

A computer code was developed to analyze any turbomachinery coolant flow path geometry that consist of a single flow passage with a unique inlet and exit. Flow can be bled off for tip-cap impingement cooling, and a flow bypass can be specified in which coolant flow is taken off at one point in the flow channel and reintroduced at a point farther downstream in the same channel. The user may either choose the coolant flow rate or let the program determine the flow rate from specified inlet and exit conditions. The computer code integrates the 1-D momentum and energy equations along a defined flow path and calculates the coolant's flow rate, temperature, pressure, and velocity and the heat transfer coefficients along the passage. The equations account for area change, mass addition or subtraction, pumping, friction, and heat transfer.

Author

N90-27723# Aix-Marseilles Univ. (France). Inst. de Mecanique Statistique de la Turbulence.

DEVICE FOR THE DILUTION OF HOT EXHAUST JETS Final Report [DILUEUR DE JET CHAUD]

R. DUMAS, M. P. CHAUVE, and M. AMIELH Nov. 1989 309 p In FRENCH

(Contract DRET-88-045)

(ETN-90-97435) Avail: NTIS HC A14/MF A02

The results of the study performed for reducing the heat from helicopter exhaust nozzles are presented. The aim of the work is to improve the existent devices for the dilution of hot air exhaustion. A simple model of dilution device is studied. Data for the validation of the calculation codes is obtained. Several exhaust system configurations were investigated. The code allows the simulation and optimization of the flow rate in a given exhaust system.

ESA

N90-27928# Naval Postgraduate School, Monterey, CA.

REGRESSION AND COMBUSTION CHARACTERISTICS OF BORON CONTAINING FUELS FOR SOLID FUEL RAMJETS

A. KARADIMITRIS, C. SCOTT, II, D. NETZER, and A. GANY (Technion - Israel Inst. of Tech., Haifa.) /In Johns Hopkins Univ., The 26th JANNAF Combustion Meeting, Volume 1 p 355-369 Oct. 1989

(Contract N60530-87-WR-30009)

Avail: NTIS HC A23/MF A03

A windowed, two-dimensional solid fuel ramjet motor was utilized with high speed motion picture cameras to study the effects of fuel composition, pressure and air mass flux on the surface behavior of metallized fuels within both the recirculation and boundary layer combustion regions. The objective was to determine if observed surface behavior and near-surface combustion

characteristics could be used to help explain the regression rate and/or performance characteristic observed in actual motor hardware. Fuels containing no combustion catalyst tested at a nominal air mass flux of 0.5 lbm/sq in. sec exhibited the characteristic of having lower combustion pressure limits with lower values of Shore A hardness. Previous observed effects of carbon black, and the observed surface reactions with bimetallic fuels indicated that ignition/flammability limits are a strong function of surface pyrolysis processes within the recirculation region. Multi-compositioned fuel grains may prove beneficial for obtaining the best combination of ignition/flammability limits and motor performance. Most metallized fuels exhibited shedding of flakes of (unburned) material from the fuel surface. Flake thickness for boron fuels was typically 200 microns, independent of pressure, and surface areas varied from less than one sq mm to approximately 22 sq mm. The mass losses attributable to the flaking process play a major role in the overall fuel mass loss mechanism. Bimetallic fuels and fuels containing a combustion catalyst apparently had surface reactions which increase the surface temperature. This should be beneficial for obtaining more complete combustion of the metals within the motor.

Author

N90-27931# California State Univ., Sacramento. Dept. of Mechanical Engineering.

CALCULATION OF THE COMBUSTION DISTRIBUTION IN A LIQUID-FUEL RAMJET

FREDERICK H. REARDON and RICHARD J. CLIFFORD (Aerojet TechSystems Co., Sacramento, CA.) /In Johns Hopkins Univ., The 26th JANNAF Combustion Meeting, Volume 1 p 393-402 Oct. 1989

Avail: NTIS HC A23/MF A03

A numerical investigation of the steady-state flow in a liquid-fuel ramjet combustor was conducted. A coaxial dump combustor was considered that is similar to the apparatus used in the experimental program conducted at the Air Force Wright Aeronautical Laboratories (AFWAL). Fuel is injected through orifices in the inlet tube wall upstream of the dump plane. Calculation of the axial combustion distribution involved three steps: prediction of the mean drop size and spatial distribution of the liquid drops, numerical calculation of the mean flow field, and integration across the combustor cross-section to determine the mean temperature as a function of distance from the dump plane. The atomization of the fuel injection streams was calculated on the basis of earlier analyses by Mayer and Adelberg. A computer program was written to calculate the mean drop size, the droplet formation rate, and the trajectory of the liquid stream. The flow field in the combustor, assumed to be axisymmetric, was determined using the FLUENT computer code. A uniform air flow in the inlet duct was assumed. The fuel spray was represented by ten droplet sources in the inlet duct along the calculated liquid stream trajectory. The output from the FLUENT program included profiles of temperature, velocity, and concentrations of reactants and products at uniformly distributed locations along the length of the combustor. The temperature profiles were integrated over the combustor cross-section to obtain a longitudinal distribution of the mass-mean temperature. From this distribution, the corresponding distribution of combustion efficiency was determined and compared with the AFWAL experimental data. Good agreement was obtained. This procedure will allow the estimation of the total combustion time lag, which is useful in the analysis of very-low-frequency combustion instability in ramjet engines, but for which experimental data are lacking.

Author

N90-27932# California State Univ., Sacramento. Dept. of Mechanical Engineering.

ENTROPY WAVE INSTABILITY IN COMPACT RAMJETS

LUC BAUWENS and JOHN W. DAILY (Colorado Univ., Boulder.) /In Johns Hopkins Univ., The 26th JANNAF Combustion Meeting, Volume 1 p 403-412 Oct. 1989

Avail: NTIS HC A23/MF A03

A stability analysis is presented, for a ramjet combustor which was extensively investigated experimentally. The Mach number is low, pressure oscillations are large, and frequencies are lower

than acoustics. The flame periodically reaches the exhaust nozzle. The data are consistent with a slow modulation of the total mass of mixture in the system. This oscillation interferes with the entropy of the fluid. A linear and nonlinear stability analysis is developed for this bulk/entropy mode. Results show it to be unstable provided the burning rate decreases sufficiently strongly with increasing combustor inlet velocity. Author

N90-27933# Naval Postgraduate School, Monterey, CA.

AN INVESTIGATION OF SOLID-FUEL, DUAL-MODE COMBUSTION RAMJETS

C. VAUGHT, M. WITT, D. NETZER, and A. GANY (Technion - Israel Inst. of Tech., Haifa.) / In Johns Hopkins Univ., The 26th JANNAF Combustion Meeting, Volume 1 p 413-429 Oct. 1989 (Contract N60530-87-WR-30009)
Avail: NTIS HC A23/MF A03

An investigation into the feasibility of using a solid fuel, dual-combustion mode ramjet (DMRJ) in high Mach number vehicles (i.e., tactical missiles) was conducted to determine the regimes where this propulsion plant might be superior to a conventional solid fuel ramjet (SFRJ). The analysis showed that at Mach 6 and 80,000 feet, with a combustion efficiency of 90 percent, the DMRJ performance can exceed that of the SFRJ by as much as 20 percent at near stoichiometric overall fuel-to-air ratios, neglecting mixing losses in the supersonic combustor. It also appears that the combustion efficiency must be greater than 70 percent in order for the DMRJ to outperform the conventional SFRJ. Chemical kinetics considerations revealed that the dual-mode configuration enables the efficient use of solid hydrocarbon fuels due to the existence of highly reactive species in the supersonic chamber, after the completion of the initial slow reaction stages in the subsonic gas generator. Preliminary laboratory tests demonstrated the operation of such a DMRJ system, including the establishment of sustained combustion in the supersonic chamber. Author

N90-28069# Rolls-Royce Ltd., Derby (England).

THE ROLE OF NDI IN THE CERTIFICATION OF TURBINE ENGINE COMPONENTS

R. G. TAYLOR, SHARON I. VUKELICH, and THOMAS D. COOPER (Wright Research Development Center, Wright-Patterson AFB, OH.) / In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 5 p May 1990 Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

During the past few years, the UK and USA have developed different approaches in the use of nondestructive inspection (NDI) in the certification and life estimation of aircraft gas turbine engine components. While both countries have utilized a fracture mechanics philosophy on critical rotating components, the use of NDI has been significantly different. The USA has developed NDI technology to be utilized in a quantitative role where the size of the defect that must be detected to meet the life estimate objectives can demonstrably be achieved to an agreed level of confidence. This approach was defined in the USA in a mil standard under the Engine Structural Integrity Program (ENSIP), and is now a mandatory requirement for all future USAF power plants. In the UK, the approach was to utilize NDI in a process monitoring role having first established, by intense NDI application together with process defect hazard reviews during the process development, that the process is under control. The historical reasons for the different approaches, the current status of these activities are highlighted, and finally, the future developments which may have the effect of minimizing the differences which exist, are addressed. Author

N90-28073# Air Force Systems Command, Wright-Patterson AFB, OH.

CRITICAL INSPECTION OF HIGH PERFORMANCE TURBINE ENGINE COMPONENTS: THE RFC CONCEPT

BRUCE A. RASMUSSEN, ERIC L. POHLENZ, JAMES D. HOFFEL, and DENA G. WILLIAMS (Systems Research Labs., Inc., Dayton,

OH.) / In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 7 p May 1990 (Contract F33615-81-C-5002)
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The U.S. Air Force has implemented a new maintenance philosophy, known as Retirement for Cause (RFC), to extend the usefulness of gas turbine engine disks and spacers beyond their original design life. Essential to the successful implementation of this philosophy was the development of a generic, totally-automated engine part inspection system that could reliably detect 5 mil flaws and determine a part's accept/reject status using critical flaw size criteria. Initial implementation of the RFC Inspection System on the Pratt and Whitney F100 engine has significantly reduced the U.S. Air Force engine spare parts inventory requirement and has resulted in a large savings in procurement costs. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A90-46483

PARAMETRIC SYNTHESIS OF THE DECOUPLING FILTER IN THE MANUAL CONTROL SYSTEM OF VTOL AIRCRAFT [PARAMETRICHESKII SINTEZ RAZVIAZYVAIUSHCHEGO FIL'TRA V SISTEME RUCHNOGO UPRAVLENIIA SAMOLETOM S VERTIKAL'NYM VZLETOM I POSADKOI]

A. I. BOGOMOLOV and P. K. SEMENOV Aviaionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 20-24. In Russian.
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An approach to the synthesis of a decoupling filter for the manual control system of VTOL aircraft is presented which makes it possible to simplify the piloting techniques during takeoff and landing by decoupling controls in the velocity parameter channels. In accordance with the approach proposed here, the problem is reduced to that of determining matrix elements for which good decoupling is achieved and constraints are satisfied for the control actions. Results of the calculations are presented. V.L.

A90-46569

DETERMINATION OF THE EXTREME VALUES OF THE EFFICIENCY CRITERIA FOR A FLIGHT VEHICLE CONTROL SYSTEM IN THE PROBABLE SCATTER RANGE OF ITS CHARACTERISTICS [OPREDELENIE EKSTREMAL'NYKH ZNACHENII KRITERIEV EFFEKTIVNOSTI SISTEMY UPRAVLENIIA LETATEL'NOGO APPARATA V OBLASTI VEROIATNYKH RAZBROSOV EGO KHARAKTERISTIK]

V. I. KOBZEV, V. N. KOSTRIKIN, and S. N. SUPRUNENKO TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 48-59. In Russian. refs
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A method is presented for estimating possible changes in the efficiency of a flight vehicle control system due to deviations of its real characteristics (aerodynamic, structural, and service) from the nominal design values. The approach is based on finding the limiting values of the efficiency criterion of the control system over a set of probable deviations of the flight vehicle characteristics. In particular, attention is given to the case where the scatter of the characteristics is described by a normal probability distribution and the scatter dependence of the efficiency criterion can be modeled by a multidimensional polynomial of second degree. V.L.

A90-46570

SELF-INDUCED ROLL OSCILLATIONS OF LIFTING SYSTEMS WITH THIN DELTA WINGS [AVTOKOLEBANIYA PO KRENU NESUSHCHIKH SISTEM S TONKIMI TREUGOL'NYMI KRYL'IAMI]

E. A. KARAVAEV and I. U. A. PRUDNIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 60-70. In Russian. refs

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The paper reports results of an experimental study of self-induced roll oscillations of thin delta wings and schematized lifting systems in which such regimes are generated by a canard-type noseplane configuration. The ranges of angles of attack and the upper bound on the delta wing span, which limit regimes with roll excitation, are determined. A relationship is established between these bounds and characteristic vortex flow regimes. V.L.

A90-46571

A METHOD FOR REDUCING A BUCKLED SKIN UNDER COMBINED LOADING [METODIKA REDUTSIROVANIYA POTERIAVSHEI USTOICHIVOSTI' OBSHIVKI PRI KOMBINIROVANNOM NAGRUZHENII]

G. N. ZAMULA and K. M. IERUSALIMSKII TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 71-82. In Russian. refs

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A method for reducing the skins of reinforced aircraft structures is proposed whereby a real buckled skin section is replaced by an equivalent-stiffness unbuckled plate of a nonlinearly elastic material of general kind. Formulas for reduction coefficients are presented for the case of the combined loading of a skin in tension and shear. The analytical results are found to be in good agreement with experimental data. V.L.

A90-46572

AN EXPERIMENTAL STUDY OF INSTANTANEOUS VELOCITY PERTURBATIONS OVER A ROTOR DISK FOR LOW DUTY COEFFICIENTS [EKSPERIMENTAL'NOE ISSLEDOVANIIE MGNOVENNYKH VOZMUSHCHENII SKOROSTI PO DISKU NESUSHCHEGO VINTA PRI MALYKH ZNACHENIIAKH KOEFFITSIENTA REZHIMA EGO RABOTY]

V. E. BASKIN, V. P. BUTOV, and L. S. PAVLOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 83-88. In Russian.

Copyright

Experimental results are presented to support results of earlier studies concerning the existence of essentially inhomogeneous downwash. Data are also presented on previously unknown abrupt fluctuations of the velocity vector of flow incident on blade sections. A comparison of measurements and visual studies shows that these fluctuations result from the interaction of vortices shed from the blade corners near the 90- and 270-deg azimuths. V.L.

A90-46577

ANALYTICAL STUDIES OF THE TRANSONIC FLUTTER OF AIRCRAFT [RASCHETNYE ISSLEDOVANIYA TRANSVUKOVOGO FLATTERA SAMOLETA]

S. I. KUZ'MINA TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 110-115. In Russian.

Copyright

The pressure coefficient and aerodynamic derivative of oscillating swept-back and swept-forward wings are calculated as a function of the Mach number using a program based on a numerical method for solving stationary Euler equations. By using this program and adopting the 'one-dimensional stationarity' hypothesis, a solution is obtained for the problem of determining the critical dynamic head of transonic flutter. The results are compared with those obtained by the panel method for subsonic flight velocities. V.L.

A90-46715

NUMERICAL ANALYSIS OF NATURAL VIBRATIONS OF AN AEROPLANE WITH SYMMETRICALLY VARIABLE GEOMETRY WING

J. BLASZCZYK (Wojskowa Akademia Techniczna, Warsaw, Poland) Journal of Technical Physics (ISSN 0324-8313), vol. 30, no. 1, 1989, p. 89-106. refs

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The longitudinal symmetric natural vibrations of an airplane which is symmetric about the 0xz plane is considered. The movable parts and the center section of the wing and the tail plane undergo torsional and flexural vibrations, and the deformable parts of the fuselage undergo flexural vibration in the symmetry plane of the aircraft. The dynamic equilibrium equations of the deformable subassemblies of the aircraft are derived, as well as the kinematic coupling conditions between them. A global set of equations are obtained, the solution of which give the required frequencies and the relevant symmetric modes of the structure with symmetrically variable sweepback. The frequency spectrum of a jet plane designed by Mikoyan is studied by numerical means. The influence of some geometrical and mass parameters on the dynamic properties of the plane is analyzed. S.A.V.

A90-46716

ANALYSIS OF SELF-EXCITED VIBRATIONS OF STIFFENED COVERING PANELS OF AN AEROPLANE WING

A. OLEJNIK (Wojskowa Akademia Techniczna, Warsaw, Poland) Journal of Technical Physics (ISSN 0324-8313), vol. 30, no. 1, 1989, p. 119-137. refs

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The static and dynamic aeroelastic stability of the stiffened panels of a supersonic aircraft is studied by the finite element method in its displacement version. The wing panels are discretized into finite plate elements of various forms and beam elements of bending and torsional rigidity. It is assumed that the surface of the panel is acted upon by a pressure difference due to motion in the flow and a variable pressure due to a disturbance independent of the plate vibration considered. The equilibrium equations of a panel element are derived using the Lagrange equations of the second kind. Methods are then presented for solving problems of self-excited vibration of square plates in supersonic flow. A computer program called FLATL is developed and used for computing the critical parameters of plates in supersonic flow in a geometrically linear range. The program is based on the inverse iteration method used for computing eigenvalues and eigenvectors, and demonstrates good numerical stability. S.A.V.

A90-46931#

FAULT TOLERANT ARCHITECTURE FOR A FLY-BY-LIGHT FLIGHT CONTROL COMPUTER

KEVIN THOMPSON, JOHN STIPANOVICH, BRIAN SMITH, and MAHESH REDDY (Boeing Aerospace and Electronics, Seattle, WA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 8 p.

The next generation of flight control computers will utilize fiber optic technology to produce a fly-by-light flight control system. Optical transducers and optical fibers will take the place of electrical position transducers and wires, torsion bars, bell cranks, and cables. Applications for this fly-by-light technology include space launch vehicles, upperstages, spacecraft, and commercial/military aircraft. Optical fibers are lighter than mechanical transmission media and unlike conventional wire transmissions are not susceptible to EMI and high energy emission sources. This paper will give an overview of a fault tolerant in-line monitored optical flight control system. This system uses passive transducers with fiber-optic interconnections which promise to virtually eliminate EMI threats to flight control system performance and flight safety, and also provide significant weight savings. Author

A90-46934#

THE SERVO FLAP - AN ADVANCED ROTOR CONTROL SYSTEM

ANDREW Z. LEMNIOS and ROBERT JONES (Kaman Aerospace Corp., Bloomfield, CT) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 38 p. refs

A conceptual design of a high maneuverability/agility rotor control system is presented. The design was created to satisfy stated Army goals for Future Attack Rotorcraft (FAR) requirements. The UH-60A rotor was selected as the baseline for comparison. Key to the design of the advanced rotor is a bearingless/hingeless blade controlled near its outboard end by dual servo flaps. The servo flaps are within blade airfoil contour and planform. Individual electrohydraulic actuators are used to control the servo flaps for primary and multicyclic (nonharmonic) motions. The conceptual design can satisfy the FAR requirements and represents a significant advancement in rotor control technology with minimal risk. Author

A90-46948#

MDHC TECHNICAL ASSESSMENT OF ADVANCED ROTOR AND CONTROL CONCEPTS

FRIEDRICH K. STRAUB (McDonnell Douglas Helicopter Co., Mesa, AZ) and DONALD J. MERKLEY (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 18 p. refs

This paper summarizes the results of an effort to incorporate, integrate and synthesize newly available and emerging technologies to produce candidate designs which promise significant improvements in rotor capability. All of the concepts considered were aimed at achieving high agility, maneuverability and survivability while also seeking to optimize critical operational characteristics of helicopters. The work included a technology assessment based on a Government formulated concept and an alternative concept developed by McDonnell Douglas Helicopter Company. These concepts considered such rotor configuration issues as: hub, blade retention, and pitch torsion arrangements; blade geometry; control system architecture; on-rotor control; stationary-to-rotating control transfer; applicability to Higher Harmonic Control and Individual Blade Control; and redundancy and vulnerability of control elements. System issues were also considered: size, weight, volume, power required; producibility, maintainability, availability, and reliability; interface requirements; and computer processing and hardware requirements. The two concepts were sized for the Apache and compared with the standard AH-64A helicopter. Significant improvements were demonstrated with additional gains possible after further risk reduction research and development programs. Author

A90-46949#

BHTI'S TECHNICAL ASSESSMENT OF ADVANCED ROTOR AND CONTROL CONCEPTS

NOLAN B. PHILLIPS (Bell Helicopter Textron, Inc., Fort Worth, TX) and DONALD J. MERKLEY (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 15 p. Research supported by the U.S. Army. refs

The results of a study to identify, integrate, and synthesize recently available technologies to develop candidate rotor/control designs are presented. Advanced rotor and control system (ARCS) concepts that could support the development of rotorcraft with high agility, maneuverability, and survivability are evaluated. Rotor configuration issues examined are hub, blade retention, pitch/torsion arrangement, control system architecture, on-rotor control, stationary-to-rotating control transfer, applicability to higher harmonic control/individual blade control, and redundancy and vulnerability of control elements. The evaluation matrix selected emphasized the technologies needed for the implementation of the ARCS concepts. Technology issues that will require the highest research priority include servo-aeroelastic stability analysis, rotor blade/servo flap system structural design, blade flexure moment

control, a fiber optic rotating joint, and a hub feathering spring dual index. R.E.P.

A90-46956#

HELICOPTER INDIVIDUAL BLADE CONTROL THROUGH OPTIMAL OUTPUT FEEDBACK

MARK E. WASIKOWSKI, DANIEL P. SCHRAGE, and ANTHONY J. CALISE (Georgia Institute of Technology, Atlanta) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 11 p. refs (Contract DAAL03-88-C-0003)

This paper presents an application of optimal output feedback control techniques to helicopter individual blade control (IBC). The controller architecture is based on a recent extension of optimal output feedback control theory to the design of fixed gain controllers for periodic systems. Constant feedback gains based on available rotor sensor measurements are calculated by minimizing a linear quadratic performance index using Floquet theory. The theory is applied to articulated rotor flap/lag stabilization, high speed hingeless rotor lag damping augmentation, and ground resonance suppression. It is shown that fixed gain output feedback can be used for stability augmentation of helicopter rotor systems. The implementation complexity associated with individual blade control is considerably reduced relative to previous formulations. Author

A90-46966*# McDonnell-Douglas Helicopter Co., Mesa, AZ.

A STUDY OF FUNDAMENTAL ISSUES IN HIGHER HARMONIC CONTROL USING AEROELASTIC SIMULATION

LAWSON H. ROBINSON (McDonnell Douglas Helicopter Co., Mesa, AZ) and PERETZ P. FRIEDMANN (California, University, Los Angeles) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 15 p. Research supported by McDonnell Douglas Helicopter Co. refs (Contract NAG2-477)

This paper describes a higher harmonic control (HHC) study of a four-bladed helicopter rotor using a coupled flap-lag-torsional aeroelastic stability and response analysis which incorporates finite-state, time-domain aerodynamics. The rotor trim condition is determined using a simplified flap-lag-torsional aeroelastic analysis. Deterministic and cautious controllers based on local and global HHC models are implemented to reduce 4/rev hub loads on roughly equivalent articulate and hingeless rotors. Results obtained for the case when the objective function requires reduction of hub shears alone are compared with results obtained when hub shears and moments are reduced simultaneously. The effects of HHC on blade aeroelastic stability are also considered. Finally, the power requirements for implementing HHC on a hingeless rotor are compared with those obtained for an articulated rotor. It is concluded that hingeless rotors require considerably more power and higher control angles than comparable articulated rotors. Author

A90-46967#

VIBRATION REDUCTION ON SERVO FLAP CONTROLLED ROTOR USING HHC

FU-SHANG WEI, JOHN P. BASILE, and ROBERT JONES (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 11 p. refs

The use of higher harmonic control (HHC) input for vibration reduction on the servo flap controlled rotor is discussed. Three types of transfer functions are utilized to predict the HHC requirements during flight including bending moment transfer functions, hub shear transfer functions, and regression equation transfer functions based on blade bending moments. A reconfigured SH-2F helicopter was used to acquire HHC effectiveness on the servo flap main rotor, and the required HHC was computed through use of generalized inverse and exact solution techniques. Both fixed and rotated systems are examined, and results show that the the blade vibration level is significantly reduced using HHC. It

is suggested that this approach be applied to aid in the reduction of helicopter vibration on the servo flap controlled rotor for future flight test programs. L.K.S.

A90-46976#

COMPARISON OF ACTIVE CONTROL ON A SERVO FLAP ROTOR USING FIXED SYSTEM AND ROTATING SYSTEM PARAMETERS

ROBERT JONES and DAVID WILL (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 7 p.

A comparison is made between using fixed system transfer function and rotating transfer functions for determining HHC inputs to improve vibration levels. The derivation of theoretical hub forces and theoretical 4 per rev hub moments is discussed, and equations used to obtain the derivative matrix for each speed are presented. A series of tables containing results are listed and discussed. It was determined that using tube load derivatives is an effective means of obtaining the required higher harmonic control to reduce 4 per rev forces and moments and, therefore, reduce tube loads even though the 5 per rev bending moment on the blades increases. A comparison of the two procedures indicates that using rotating parameters may be the best approach to improving vibration levels. L.K.S.

A90-47309*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MECHANISMS OF ACTIVE CONTROL IN CYLINDRICAL FUSELAGE STRUCTURES

RICHARD J. SILCOX, HAROLD C. LESTER (NASA, Langley Research Center, Hampton, VA), and CHRIS R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, Aug. 1990, p. 1397-1404. Previously cited in issue 04, p. 442, Accession no. A88-16555. refs

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A90-47576

AIAA GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, PORTLAND, OR, AUG. 20-22, 1990, TECHNICAL PAPERS. PARTS 1 & 2

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. Pt. 1, 899 p.; pt. 2, 950 p. For individual items see A90-47577 to A90-47607, A90-47609 to A90-47699, A90-47701 to A90-47762.

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Recent advances in aircraft and spacecraft guidance, navigation, and control (GNC) technology are discussed in reviews and reports. Sections are devoted to control systems for the Space Station Freedom, control of flexible structures, guidance algorithms and analysis, aircraft control, missile guidance and control, computational dynamics and control, navigation algorithms and analysis, GNC for the ESA Columbus program, and space robotics. Consideration is given to tracking and estimation algorithms, launch-vehicle guidance and control, GNC components, spacecraft slewing and pointing control, AI applications, optimization and optimal control, differential games, space-vehicle GNC, actuator placement and structural identification, linear-system control, man-in-the-loop flight control, spacecraft attitude dynamics and control, structural control experiments, and the analysis and synthesis of robust controllers. T.K.

A90-47590#

APPLICATION OF ENERGY TURN G-LIMITING FOR AIRCRAFT HIGH PERFORMANCE TURNS

ANTHONY WARREN (Boeing Aerospace and Electronics, Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 125-133. refs (AIAA PAPER 90-3328) Copyright

Guidance algorithms for performing real-time high-g

three-dimensional turn maneuvers in high-performance aircraft are described. The key idea in implementing such turns is to use g-limiting to obtain an optimal tradeoff between turn rate and energy rate which minimizes maneuver time. In the special case of constant-altitude constant-speed turning, the algorithms implement sustained-energy turning at max thrust. In more complex three-dimensional turns, the algorithms determine bank-angle and load-factor commands which implement climbing/diving energy turns. Two techniques were examined for turn-maneuver g-limiting: (1) singular-perturbation energy-turn theory and (2) simultaneous capture of final energy and heading. Comparisons with results from an off-line optimization code in a 180-deg diving turn maneuver show that both techniques minimize maneuver time within 10 percent of the optimal trajectory. However, (2) is preferred since energy management is closer to the optimal. Author

A90-47593#

ROBUST HOVER CONTROL FOR A SHORT TAKEOFF/VERTICAL LANDING AIRCRAFT

RANDAL K. DOUGLAS (Texas, University, Austin; General Dynamics Corp., Fort Worth), STEVEN A. MACKLER (Texas, University, Austin), and JASON L. SPEYER (California, University, Los Angeles) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 150-163. refs (AIAA PAPER 90-3333) Copyright

Robust control issues for the transition-to-hover mode of the E7 STOVL aircraft designated are investigated. An analysis of the open-loop dynamics shows which of the available control effectors are needed to achieve control authority. A controllable state space is formed, and a linear-quadratic-Gaussian compensator is designed to guarantee zero command-tracking error. An asymptotic LQR robustness recovery procedure is used to ensure good multivariable robustness with respect to unstructured uncertainties such as unmodeled higher-order actuator dynamics and wind-gust disturbances. An $H(\infty)$ game-theoretic controller then is designed and compared with the LQG/LTR design. Both designs use the same sensors and controls. A time-domain analysis demonstrates the stability robustness of both compensators with respect to structured and unstructured plant uncertainties. Author

A90-47594#

APPLICATION OF A DESIGN METHOD FOR INTEGRATED CONTROL TO A VTOL AIRPLANE IN HOVER

B. L. STAUFFER, R. A. STUEVER, and J. L. VIAN (Boeing Military Airplanes, Wichita, KS) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 164-182. refs (AIAA PAPER 90-3334) Copyright

A design methodology for integrated control of next-generation tactical VTOL aircraft is assessed through an application of the methodology. The method uses hierarchical distributed controllers to partition the overall system into independent, transparent subsystem designs. Generalized controls and generalized actuators, in place of the actual subsystems, are used with nonspecific controller synthesis methods to design for overall system performance. The closed-loop generalized actuators provide the performance requirements for the subsystems. Subsystems can then be redesigned or their inner-loop controls developed such that performance requirements are met. Different controller synthesis methods, including output feedback with eigenstructure assignment, are used in the application to obtain closed-loop distributed controllers for a VTOL vehicle in hovering flight. Author

A90-47595*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

H-INFINITY BASED INTEGRATED FLIGHT/PROPULSION CONTROL DESIGN FOR A STOVL AIRCRAFT IN TRANSITION FLIGHT

SANJAY GARG, DUANE L. MATTERN (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), MICHELLE BRIGHT, and PETER OUZTS (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 183-193. refs
(AIAA PAPER 90-3335) Copyright

This paper presents results from an application of $H(\infty)$ control design methodology to a centralized integrated flight/propulsion control (IFPC) system design for a supersonic STOVL fighter aircraft in transition flight. The overall design methodology consists of a centralized IFPC design with controller partitioning. Design and evaluation vehicle models are summarized, and insight is provided into formulating the $H(\infty)$ control problem such that it reflects the IFPC design objective. The $H(\infty)$ controller is shown to provide decoupled command tracking for the design model. The controller order could be significantly reduced by modal residualization of the fast controller modes without any deterioration in performance. Author

A90-47596#

STOL MANEUVER TECHNOLOGY DEMONSTRATOR AEROSERVOELASTICITY

PETER Y. CHENG, ROBERT C. JONES, and STEPHEN M. MURNYACK (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 194-199. (AIAA PAPER 90-3336) Copyright

The aeroservoelasticity (ASE) of the STOL Maneuver Technology Demonstrator is discussed with emphasis on ASE analysis, structural mode compensation, and related tests performed on the aircraft. Detailed modeling and analysis of the digital flight-control system aerodynamics, and structural modes required a team effort from individuals in aerodynamics/propulsion, structural dynamics, and control dynamics. ASE analysis and subsequent structural mode interaction tests proved to be essential in uncovering and eliminating instability due to ASE interaction. Modeling techniques, results from analysis, and ground and flight test results are presented. Author

A90-47597*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ACTIVE CONTROL OF AEROTHERMOELASTIC EFFECTS FOR A CONCEPTUAL HYPERSONIC AIRCRAFT

JENNIFER HEEG, MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA), and ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 200-208. refs
(AIAA PAPER 90-3337) Copyright

This paper describes the procedures for an results of aeroservoelastoc studies. The objectives of these studies were to develop the necessary procedures for performing an aeroelastic analysis of an aerodynamically heated vehicle and to analyze a configuration in the classical 'cold' state and in a 'hot' state. Major tasks include the development of the structural and aerodynamic models, open loop analyses, design of active control laws for improving dynamic responses and analyses of the closed loop vehicles. The analyses performed focused on flutter speed calculations, short period eigenvalue trends and statistical analyses of the vehicle response to controls and turbulence. Improving the ride quality of the vehicle and raising the flutter boundary of the aerodynamically-heated vehicle up to that of the cold vehicle were the objectives of the control law design investigations. Author

A90-47598#

ROBUSTNESS OF DYNAMIC INVERSION VS MU SYNTHESIS - LATERAL-DIRECTIONAL FLIGHT CONTROL EXAMPLE

DALE ENNS (Honeywell Systems and Research Center, Minnesota, University, Minneapolis) IN: AIAA Guidance, Navigation and

Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 210-222. refs
(AIAA PAPER 90-3338) Copyright

This paper will discuss robustness analysis of control laws for the lateral-directional axes of an aircraft. Two control laws are compared. One control law was developed with dynamic inversion and the other was developed with structured singular value of mu synthesis. The comparison is based on nominal performance, robust stability, robust performance using frequency response analysis and time histories of responses to pilot commands. Nominal performance is defined in terms of handling qualities and includes turn coordination. Robust stability is analyzed with single loop at a time Bode and Nyquist plots for all actuator and sensor locations, and with singular values corresponding to multiplicative uncertainty at the actuator location. Robust performance is analyzed with the structured singular value for the degradation of handling qualities in the presence of the multiplicative actuator uncertainty. Author

A90-47627#

SINGULAR, PERIODIC SOLUTIONS IN AIRCRAFT CRUISE-DASH OPTIMIZATION

K. R. SUWAL and E. M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 487-492. Research supported by DARPA. refs
(Contract F49620-87-C-0016)
(AIAA PAPER 90-3369) Copyright

The cruise-dash problem can be viewed as that of minimizing fuel while maintaining a specified average speed. Periodic solutions are shown to exhibit singular throttle behavior. The character of these solutions is examined for a range of specified speeds. Author

A90-47628#

INVERSION OF NONLINEAR I-O MAP, ZERO DYNAMICS AND FLIGHT CONTROL SYSTEM DESIGN

JAMES J. ROMANO and SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 493-498. refs
(Contract DAAL03-87-G-0004)
(AIAA PAPER 90-3370) Copyright

The question of trajectory control of aircraft in rapid nonlinear maneuvers is treated. Based on nonlinear invertibility theory, a control law is derived to independently control roll, pitch, and sideslip angles using rudder, elevator, and aileron. Integral feedback is introduced to obtain control-system robustness to parameter uncertainty. The stability of the zero dynamics is examined. Simulation results are presented to show that, in the closed-loop system, precise simultaneous lateral and longitudinal maneuvers can be performed in spite of the presence of uncertainty in the stability derivatives. Author

A90-47629#

MULTIVARIABLE CONTROL LAW FOR FLAT-TURN STRATAFING MANEUVER BY A SUPERMANEUVERABLE AIRCRAFT

CHIEN Y. HUANG (Grumman Corporate Research Center, Bethpage, NY) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 499-506. refs
(AIAA PAPER 90-3371) Copyright

A control law that allows a supermaneuverable aircraft to perform flat-turn stratafing maneuver is described. It is based on proportional-integral model-following concepts, which has inherent advantage of quickly obtaining a design that has satisfactory performance. The control law is applied to an advanced fighter

aircraft and simulation results show that flat-turn strafing maneuvers are possible with the use of the model-following control law.

Author

A90-47630*# Systems Technology, Inc., Mountain View, CA.
REAL-TIME PILOTED SIMULATION OF FULLY AUTOMATIC GUIDANCE AND CONTROL FOR ROTORCRAFT NAP-OF-THE-EARTH (NOE) FLIGHT FOLLOWING PLANNED PROFILES

WARREN F. CLEMENT, PATER J. GORDER, WAYNE F. JEWELL (Systems Technology, Inc., Mountain View, CA), and RICHARD COPPENBARGER (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 507-517. refs (Contract NAS2-12640)

(AIAA PAPER 90-3372) Copyright

Developing a single-pilot all-weather NOE capability requires fully automatic NOE navigation and flight control. Innovative guidance and control concepts are being investigated to (1) organize the onboard computer-based storage and real-time updating of NOE terrain profiles and obstacles; (2) define a class of automatic anticipative pursuit guidance algorithms to follow the vertical, lateral, and longitudinal guidance commands; (3) automate a decision-making process for unexpected obstacle avoidance; and (4) provide several rapid response maneuvers. Acquired knowledge from the sensed environment is correlated with the recorded environment which is then used to determine an appropriate evasive maneuver if a nonconformity is observed. This research effort has been evaluated in both fixed-base and moving-base real-time piloted simulations thereby evaluating pilot acceptance of the automated concepts, supervisory override, manual operation, and reengagement of the automatic system.

Author

A90-47631*# National Aeronautics and Space Administration.
 Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT TEST OF A TRAJECTORY CONTROLLER USING LINEARIZING TRANSFORMATIONS WITH MEASUREMENT FEEDBACK

ROBERT F. ANTONIEWICZ, EUGENE L. DUKE (NASA, Flight Research Center, Edwards, CA), and P. K. A. MENON (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 518-532. refs

(AIAA PAPER 90-3373) Copyright

The design of nonlinear controllers has relied on the use of detailed aerodynamic and engine models that must be associated with the control law in the flight system implementation. Many of these controllers have been applied to vehicle flightpath control problems and have attempted to combine both inner- and outer-loop control functions in a single controller. This paper presents an alternate approach to the design of outer-loop controllers. The approach simplifies the outer-loop design problem by separating the inner-loop (stabilization and control) from the outer-loop (guidance and navigation) functions. Linearizing transformations are applied using measurement feedback to eliminate the need for detailed aircraft models in outer-loop control applications. Also discussed is an implementation of the controller. This implementation was tested on a six-degree-of-freedom F-15 simulation and in flight on an F-15 aircraft. Proof of the concept is provided by flight test data which is presented and discussed.

Author

A90-47632#
IMPROVED NOISE REJECTION IN AUTOMATIC CARRIER LANDING SYSTEMS

D. JOSEPH MOOK, DOUGLAS A. SWANSON, and MICHAEL J. ROEMER (New York, State University, Buffalo) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute

of Aeronautics and Astronautics, 1990, p. 533-543. refs (AIAA PAPER 90-3374) Copyright

A technique for reducing the effect of sensor noise in a closed-loop control system is developed. The effect of radar noise on an automatic carrier landing system is studied using digital computer simulation techniques. A noise rejection filter, which blends model estimates of the plane's vertical velocity and acceleration with altitude information obtained by radar, is added to the system to decrease the sensitivity to noise. However, this results in an increased turbulence response. A control/filter variable optimization is then performed to prevent degradation of the system's response to turbulence while simultaneously achieving high noise rejection and adequate transient response.

Author

A90-47661*# Minnesota Univ., Minneapolis.
NONLINEAR INVERSION FLIGHT CONTROL FOR A SUPERMANEUVERABLE AIRCRAFT

S. ANTONY SNELL, WILLIAM L. GARRARD, JR. (Minnesota, University, Minneapolis), and DALE F. ENNS (Honeywell Systems and Research Center, Minnesota, University, Minneapolis) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 808-825. refs

(Contract NAG1-321)

(AIAA PAPER 90-3406) Copyright

This paper describes the use of nonlinear dynamic inversion for the design of a flight control system for a supermaneuverable aircraft. First, the dynamics to be controlled were separated into fast and slow variables. The fast variables were the angular rates and the slow variables were the attitude angles. Then a nonlinear inversion controller was designed for the fast variables. This stabilized the longitudinal short-period and improved the lateral-directional responses over a wide range of angle of attack by making use of a combination for aerodynamic surfaces and thrust vectoring control. Outer loops were then closed to allow the pilot to control the slow dynamics, the angle of attack, side-slip angle and the velocity bank angle. Nonlinear inversion was also used to design of the outer loop control laws. The dynamic inversion control laws were compared with more conventional, gain-scheduled control laws and were shown to yield much better performance.

Author

A90-47662#
A DYNAMIC INVERSION BASED CONTROL LAW WITH APPLICATION TO THE HIGH ANGLE-OF-ATTACK RESEARCH VEHICLE

DANIEL J. BUGAJSKI, DALE F. ENNS, and MICHAEL R. ELGERSMA (Honeywell Systems and Research Center, Minneapolis, MN) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 826-839. refs

(AIAA PAPER 90-3407) Copyright

This paper proposes a general structure for aircraft control at whose core are several blocks of dynamic inversion of the controlled system. This control law is then applied to a nonlinear model of NASA's High Angle-of-attack Research Vehicle (HARV) which is currently being studied jointly by NASA Ames, NASA Ames/Dryden, and NASA Langley. The control law itself uses the complete nonlinear aero data base, and has no restrictions on the manner in which the control inputs enter the dynamic equations. An algorithm which handles surface limiting while ensuring a solution to the moment equation inverse is incorporated into the control law. The excellent tracking performance of the control law is demonstrated via the simulation of a couple selected supermaneuvers.

Author

A90-47664#
ADAPTIVE FLIGHT CONTROL OF CCV AIRCRAFT WITH LIMITING ZEROS

K. KANAI (National Defense Academy, Yokosuka, Japan), P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada), N.

HORI (McGill University, Montreal, Canada), and Y. KISHIMOTO IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 852-862. refs

(AIAA PAPER 90-3409) Copyright

A method is described of adaptively controlling CCV aircraft using the so-called delta operator to overcome the effects of unstable limiting zeros introduced by the inclusion of actuator dynamics into the aircraft dynamics. The ideal case, where there is no discretization error, is considered first, followed by the nonideal case where the robustness of the adaptive algorithm is taken into account. The results of the simulation studies are reported and show the advantage of using the delta operator instead of the z operator. Author

A90-47665* # Princeton Univ., NJ.

STOCHASTIC PERFORMANCE ROBUSTNESS OF AIRCRAFT CONTROL SYSTEMS

ROBERT F. STENGEL (Princeton University, NJ) and LAURA RYAN RAY IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 863-873. Research supported by FAA. refs

(Contract NGL-31-001-252; DAAL03-89-K-0092)

(AIAA PAPER 90-3410) Copyright

Stochastic robustness, a simple technique used to estimate the robustness of linear, time-invariant systems, is applied to a twin-jet transport aircraft control system. Concepts behind stochastic stability robustness are extended to stochastic performance robustness. Stochastic performance robustness measures based on classical design specifications and measures specific to aircraft handling qualities are introduced. Confidence intervals for both individual stochastic robustness measures and for comparing two measures are presented. The application of stochastic performance robustness, the use of confidence intervals, and tradeoffs between performance objectives are demonstrated by means of the twin-jet aircraft example. Author

A90-47666#

ROBUST FLIGHT CONTROL SYSTEM DESIGN WITH MULTIPLE MODEL APPROACH

YOSHIKAZU MIYAZAWA (National Aerospace Laboratory, Chofu, Japan) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 874-882. refs

(AIAA PAPER 90-3411) Copyright

An approach that is introduced by combining the concepts of multiple models, LQR (linear-quadratic regulator), and proportional output feedback, is applied to robust flight-control system design. Robustness of the control system is obtained with multiple models that represent uncertain dynamics. In particular, a delay element of uncertain delay time is proposed in order to introduce a robust multiple-input control system, bandwidths of which can be assigned. The so-called loop shaping for MIMO systems is possible using this approach. Two numerical examples are shown which demonstrate that robustness is increased using the multimodel approach, as compared with the standard LQR method. Author

A90-47694#

A MIXED H_2 AND $H(\infty)$ APPROACH TO AN AUTOPILOT DESIGN PROBLEM

ANDREW SPARKS, HSI-HAN YEH, and SIVA BANDA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1129-1138. refs

(AIAA PAPER 90-3441)

This paper shows an application of a robust control technique to the design of a transport-aircraft lateral-axis autopilot. The

autopilot tracks aircraft heading in response to pilot commands, and tracks a localizer beam in preparation for landing. The technique provides a controller that is robust in the presence of both high-frequency unmodeled dynamics and real parameter variation between flight conditions. A quadratic performance index of the nominal system is minimized, while the $H(\infty)$ norm of the closed-loop transfer function of the same nominal system is constrained to provide robustness. The actual closed-loop system has performance and robustness properties that are at least as good as those of the nominal design model, regardless of the real parameter variation. Author

A90-47695#

LATERAL-DIRECTIONAL CONTROL OF AN AIRCRAFT USING MU SYNTHESIS

MIKE JACKSON and DALE ENNS (Honeywell Systems and Research Center, Minneapolis, MN) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1139-1147. refs

(AIAA PAPER 90-3442) Copyright

$H(\infty)$ and μ -synthesis (structured singular value) methods are used to develop a controller for the lateral-directional motion of an aircraft. The aircraft model used has significant coupling between roll and yaw axes; in particular, the aileron and rudder deflections produce significant off-axis responses. The controller is designed to achieve decoupling of roll rate and lateral acceleration response in the face of uncertainty. A reduced-order controller is generated, and time histories are shown both with and without a perturbed model. Author

A90-47696#

ROBUST CONTROL DESIGN FOR RELAXED STATIC STABILITY AIRCRAFT

WILLIAM H. BENNETT (Techno-Sciences, Inc., Greenbelt, MD), KEITH GLOVER (Cambridge, University, England), and HARRY G. KWANTY (Drexel University, Philadelphia, PA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1148-1158. refs

(Contract F33615-88-C-3606)

(AIAA PAPER 90-3443) Copyright

This paper describes a design method for robust control for flight-control systems subject to combined unstructured (parasitic) and structured (parametric) model uncertainty. The method is based on a maximin optimization strategy which is possible due to recent advances in robust control design based on $H(\infty)$ optimal synthesis. Central to the approach is a new understanding of stability margins for multiloop feedback systems and synthesis methods for optimizing closed-loop stability robustness. Loop-shaping design procedures are highlighted, and suggested procedures for robust control design are given. A flight-control design for relaxed static stability is considered. Author

A90-47726#

INPUT/OUTPUT COUPLING IN EIGENSTRUCTURE ASSIGNMENT

P. R. SMITH (Royal Aerospace Establishment, Bedford, England) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1450-1459. refs

(AIAA PAPER 90-3476) Copyright

Problems in the eigenstructure-assignment (EA) approach to feedback-control design for aircraft are examined analytically. The basic properties of controllable and observable linear time-invariant systems are reviewed; the null-space vectors are characterized, with a focus on the mode output and mode input coupling vectors; and an EA design method which takes both the left and right eigenvectors into account is described and applied to develop a control law for a Lynx helicopter in forward flight at speed 100 kts and altitude 100 ft. Numerical results are presented in extensive

tables and graphs and discussed in detail. The importance of I/O coupling is demonstrated, and the EA-designed controller is shown to yield good closed-loop response even when the rotor flapping modes are included. T.K.

A90-47727* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EFFECTS OF STICK DYNAMICS ON HELICOPTER FLYING QUALITIES

DOUGLAS C. WATSON and JEFFERY A. SCHROEDER (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1460-1479. refs (AIAA PAPER 90-3477) Copyright

An experiment that investigated the influence of typical helicopter force-feel system dynamics on roll-axis handling qualities was conducted in concurrent ground and inflight simulations. Variations in lateral control natural frequency and damping ratio, effected by changes in inertia and damping, were evaluated in a disturbance-rejection task. Pilot ratings indicated a preference for low-inertia feel systems, although measured performance was relatively constant over the range of stick characteristics. Force-sensing was compared with position sensing as the input to the control system. Force-sensing improved performance but did not improve pilot ratings. Overall, the results indicated that control-stick dynamics, at least within a reasonable range, did not have a significant effect on pilot-vehicle performance. However, the physical effort required to maintain a desired pilot/manipulator bandwidth became objectionable as the stick inertia increased beyond 5-7 lbf, which was reflected in the pilot ratings and comments. Author

A90-47728#

FLIGHT CONTROLLER DESIGN WITH NONLINEAR AERODYNAMICS, LARGE PARAMETER UNCERTAINTY, AND PILOT COMPENSATION

T. KOBYLARZ, I. M. HOROWITZ, C. H. HOUPIS (USAF, Institute of Technology, Wright-Patterson AFB, OH), and F. BARFIELD (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1480-1494. refs (AIAA PAPER 90-3478) Copyright

Nonlinear quantitative feedback theory is used to design a flight-control system for the nonlinear model of the YF-16 aircraft with C(asterisk) as the controlled output. The resulting closed-loop stability-augmentation system, becomes part of the outer loop containing the pilot. The Neal-Smith pilot model for a compensatory tracking task is used to develop a technique which allows the designer to synthesize compensation in the outer loop, which includes a free compensator chosen to minimize pilot workload, increase system bandwidth, and improve handling qualities ratings for the tracking task. Simulations in the time and frequency domains demonstrate that the desired performance is attained. Author

A90-47729#

SIMULATION INVESTIGATION OF MULTIPLE AXIS FLYING QUALITIES

DAVID G. MITCHELL, BIMAL L. APONSO (Systems Technology, Inc., Hawthorne, CA), and MARK J. DETROIT (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1495-1502. refs (Contract F33615-85-C-3610)

(AIAA PAPER 90-3480) Copyright

A piloted simulation was conducted on the USAF Large-Amplitude Multimode Aerospace Research Simulator to investigate the nature of piloted control in the presence of simultaneous flying qualities degradations in multiple axes. Six pilots

participated in the study, involving compensatory tracking of displayed errors in one, two, or three axes with varying vehicle dynamics. Both quantitative and qualitative performance measures were taken. The results show that adding axes to control, or increasing degradations in a single axis, produces increases in tracking error and degradations in pilot ratings. The increase in pilot ratings in going from single-axis to multiple-axis tracking is as expected from the product rule. Author

A90-47731* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT INVESTIGATION OF VARIATIONS IN ROTORCRAFT CONTROL AND DISPLAY DYNAMICS FOR HOVER

MICHELLE M. ESHOW (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1514-1526. refs

(AIAA PAPER 90-3482) Copyright

Results are presented from a flight test of experimental control/display systems for the U.S. Army/NASA CH-47B variable-stability research helicopter in hovering maneuvers, supplementing the preliminary report of Eshow et al. (1987). The display format was a simplified version of the pilot night-vision system for the Apache AH-64, and the tests measured pilot performance in hover-pad capture and hover-pad tracking tasks (under simulated zero visibility) using displays based on (1) gainlike and (2) integratorlike controlled-element responses to control inputs. The implementation of the vehicle-response dynamics through an explicit model-following control system and the derivation of the display laws are described, and the test results are presented in extensive tables and graphs. Display type (1) was found to be preferred by the pilots and to give generally better performance than type (2). T.K.

A90-47732* California Univ., Davis.

ANALYZING THE FLARED LANDING TASK WITH PITCH-RATE FLIGHT CONTROL SYSTEMS

RONALD A. HESS (California, University, Davis) and MARDUKE YOUSEFFOR IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1527-1537. refs (Contract NAG2-490)

(AIAA PAPER 90-3483) Copyright

A closed-loop handling qualities methodology is applied to an analysis of the flared landing task with pitch-rate flight control systems. A model of pilot behavior throughout approach and flare is developed which postulates the manner in which the pilot may move from pitch attitude to flight path angle control. Twenty-five configurations flight tested on the NC-131H Total In-flight Simulator aircraft are analyzed using a structural pilot model and a handling qualities methodology previously reported in the literature. Closed-loop simulation of the simplified landing task is undertaken using the structural model. The pilot ratings from flight test extended the data base supporting the utility of a model-based handling qualities metric. A handling qualities sensitivity function is introduced which may have potential as a design tool. Author

A90-47733#

A COMPARISON OF INVERSE CONTROL WITH OPTIMAL CONTROL

ETSUROH SENTOH and ARTHUR E. BRYSON, JR. (Stanford University, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1538-1549. refs

(AIAA PAPER 90-3484) Copyright

Inverse control is compared with optimal control, using as an example the slow roll of an aircraft. It is shown that this example can be analyzed using a model-following linear-inverse method of solution to the same accuracy achieved by Kato and Sugiura (1986),

using a constant roll rate. However, this example produces infeasible rudder and sideslip angle histories. Hence it is modified to require (1) that the center of mass ends up on the projected initial flight path and (2) that there be no side-force, so that the maneuver is coordinated. The model-following linear-inverse method gives feasible coordinated controls. The flight-path deviation is about 30 feet. Using the optimal control method with variable roll rate, a very similar solution is obtained, but the maximum flight path deviation is only about 19 feet. Author

A90-47734#

OPTIMAL RIGID BODY REORIENTATION PROBLEM

RAJIV S. CHOWDHRY and EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1550-1560. Research supported by DARPA. refs

(Contract F49620-87-C-0016)

(AIAA PAPER 90-3485) Copyright

The time-optimal restricted-moment attitude control of a rigid-body vehicle is investigated analytically. The dynamical model (based on the Euler equations) is described; the control problem is formulated; first-order necessary optimality conditions are derived using the minimum principle of Pontryagin; and the multiple extremal solutions indicated by this analysis are briefly characterized. Particular attention is then given to the introduction of roll control, roll around the velocity vector, a fuselage pointing maneuver, and the possibility of bang-bang control; typical numerical results are presented in graphs. The applicability of the present analysis to rapid rotational maneuvers of supermaneuverable aircraft using thrust-vectoring moment control is indicated. T.K.

A90-47736#

GENETIC ALGORITHMS IN CONTROL SYSTEM OPTIMIZATION

K. KRISHNAKUMAR and DAVID E. GOLDBERG (Alabama, University, Tuscaloosa) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1568-1577. refs

(Contract NSF CTS-84-51610)

(AIAA PAPER 90-3488) Copyright

This paper explores the use of genetic algorithm as a technique in solving aerospace-related optimization problems. Genetic algorithms are parameter search procedures based upon the mechanics of natural genetics. They combine a Darwinian survival-of-the-fittest with a random, yet structured information exchange among a population of artificial chromosomes. Variations of this technique are used in designing a lateral autopilot and a wind shear controller. The results show that a wide variety of aerospace control system optimization can be conducted using genetic algorithms with no special problem-dependent modifications to the algorithm. Author

A90-47737#

A ROBUST WIND SHEAR STOCHASTIC CONTROLLER-ESTIMATOR

J. E. BAILEY, K. KRISHNAKUMAR (Alabama, University, Tuscaloosa), and R. K. PRASANTH IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1578-1585. refs

(AIAA PAPER 90-3489) Copyright

Wind shear research conducted in the past assumed separation of control and estimation. Variations in microburst size and strength were also not incorporated in the design. This study combines microburst flight path control and state estimation in the presence of uncertainty in microburst size and strength. Variations in shaping filter parameters are computed using a wind model that agrees in spectral content with actual microbursts. Stratonovich interpretation of stochastic integrals is used to derive a coupled controller-estimator system. Verification of design robustness is

carried out using a linearized B-727 longitudinal approach flight simulation. Results are compared with a linear-quadratic Gaussian (LQG) design that does not incorporate statistical information on microbursts. The present design is shown to have superior performance than the LQG design and robust with respect to variations in microburst parameters. Author

A90-47747*# Lockheed Engineering and Sciences Co., Hampton, VA.

DEVELOPMENT AND TESTING OF METHODOLOGY FOR EVALUATING THE PERFORMANCE OF

MULTI-INPUT/MULTI-OUTPUT DIGITAL CONTROL SYSTEMS

ANTHONY S. POLOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA), CAROL WIESEMAN, SHERWOOD TIFFANY HOADLEY, and VIVEK MUKHOPADHYAY (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1673-1782. refs

(AIAA PAPER 90-3501)

The development of a controller performance evaluation (CPE) methodology for multiinput/multioutput digital control systems is described. The equations used to obtain the open-loop plant, controller transfer matrices, and return-difference matrices are given. Results of applying the CPE methodology to evaluate MIMO digital flutter suppression systems being tested on an active flexible wing wind-tunnel model are presented to demonstrate the CPE capability. K.K.

A90-47764*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT EVALUATIONS OF SEVERAL HOVER CONTROL AND DISPLAY COMBINATIONS FOR PRECISE BLIND VERTICAL LANDINGS

J. A. SCHROEDER and V. K. MERRICK (NASA, Ames Research Center, Moffett Field, CA) AIAA, Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990. 22 p. refs

(AIAA PAPER 90-3479) Copyright

Several control and display concepts were evaluated on a variable-stability helicopter prior to future evaluations on a modified Harrier. The control and display concepts had been developed to enable precise hover maneuvers, station keeping, and vertical landings in simulated zero-visibility conditions and had been evaluated extensively in previous piloted simulations. Flight evaluations early in the program revealed several inadequacies in the display drive laws that were later corrected using an alternative design approach that integrated the control and display characteristics with the desired guidance law. While hooded, three pilots performed landing-pad captures followed by vertical landings with attitude-rate, attitude, and translation-velocity-command control systems. The latter control system incorporated a modified version of state-rate-feedback implicit-model following. Precise landing within 2 ft of the desired touchdown point were achieved. Author

A90-48514#

LONGITUDINAL STABILITY ANALYSIS FOR DEFORMABLE AIRCRAFT

RUIJUAN XU (Northwestern Polytechnical University, Xian, People's Republic of China) IN: Aerospace - Collected translations of selected papers (A90-48510 22-01). Xian, People's Republic of China, Northwestern Polytechnical University, 1990, 9 p. Translation. Previously cited in issue 09, p. 1294, Accession no. A89-25934.

A90-48515#

EXCEPTIONS TO THE C(N BETA, DYN) CRITERION FOR AIRCRAFT STABILITY AT HIGH ANGLES OF ATTACK

ZHIDAI HE (Northwestern Polytechnical University, Xian, People's Republic of China) IN: Aerospace - Collected translations of selected papers. Xian, People's Republic of China, Northwestern Polytechnical University, 1990, 16 p. Translation. refs

Time history studies are developed by programming a set of

equations of motion pertinent to a typical fighter aircraft. Some aerodynamic derivatives are varied, including those connected with $C(n \text{ beta, dyn})$ and the responses of some of the variables of motion are observed. The results indicate that the aircraft may be unstable at high angles of attack even when the $C(n \text{ beta, dyn})$ criterion is satisfied. R.E.P.

A90-48882#**AN INVESTIGATION OF AIRCRAFT MANEUVERABILITY AND AGILITY**

DAN SCHRAGE (Georgia Institute of Technology, Atlanta) and FRED STELLAR AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p. refs

(AIAA PAPER 90-3300) Copyright

The maneuverability and agility of CAS (close air support) aircraft were investigated. The investigation was accomplished by expanding the capabilities of HELCOM to incorporate fixed-wing aircraft modeling. HELCOM is a series of computer programs which use energy/force balancing methods to determine helicopter maneuverability and agility parameters. HELCOM, as a tool for understanding maneuverability and agility, was improved to provide a good approximation for both rotary wing and fixed wing aircraft. The tilt-rotor concept, using XV-15 data, was compared to current CAS aircraft and shown to incorporate design features desired in highly maneuverable and agile CAS aircraft. Author

A90-48888#**SHORT TAKE-OFF AND LANDING MANEUVER TECHNOLOGY DEMONSTRATOR (STOL/MTD) LESSONS LEARNED - INTEGRATED FLIGHT/PROPULSION CONTROL (IFPC)**

BRUCE T. CLOUGH (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p.

(AIAA PAPER 90-3307)

The STOL/MTD Aircraft is completing a successful test program evaluating four technologies crucial to future aircraft faced with the task of landing on a short runway, at night, in weather, and without ground landing aids, they are: two-dimensional thrust vectoring/thrust reversing nozzles, integrated flight/propulsion controls, high sink rate/rough field landing gear, and advanced pilot displays/autonomous landing system. The IFPC, consisting of multiple processors distributed around the aircraft, was the first of these technologies to be designed, built, tested and demonstrated in flight. Lessons learned in the development of the IFPC system will help future programs avoid pitfalls, focus attention on areas sometimes ignored, recognize possible problem areas, as well as sharing what went as planned, or better. Author

A90-49110*# Systems Control Technology, Inc., Palo Alto, CA. FLIGHT CONTROL DESIGN CONSIDERATIONS FOR STOVL POWERED-LIFT FLIGHT

JAMES H. VINCENT and ROB ANEX (Systems Control Technology, Inc., Palo Alto, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 13 p. refs

(Contract NAS3-25193)

(AIAA PAPER 90-3225) Copyright

Short Takeoff Vertical Landing (STOVL) aircraft rely on the propulsion system for the lift and control functions during slow speed flight. The propulsion system provides the entire lifting force and all of the control power for hovering flight at zero airspeed. STOVL designs such as the General Dynamics E-7D ejector configuration incorporate an integrated flight/propulsion control system to manage the aerodynamic and propulsive-lift control effectors and to reduce the pilot's workload for powered-lift flight. Desired flying qualities characteristics are implemented through the utilization of an explicit model following flight control system. With the model following control system, the pilot commands the desired response (e.g., throttle commands vertical velocity in hover, instead of power lever angle). Design considerations for developing a multivariable model-following flight control system are presented

in this paper. When the regulator gains are defined in terms of generalized controls, the design problem becomes how to best transform the generalized controls to aerodynamic control surface, thrust and thrust vectoring commands. Author

A90-49111#**RECONFIGURABLE AIRCRAFT FLIGHT CONTROL SYSTEM VIA ROBUST DIRECT ADAPTIVE CONTROL**

C. M. HA (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 14 p. refs

(AIAA PAPER 90-3226) Copyright

Reconfiguration of multivariable flight control laws after surface damage, sensor and actuator failures using robust full-state direct adaptive control is studied in this paper. The reconfigurable flight controller distributes control authority among the remaining surfaces without explicit knowledge of a given failure condition. A comparison of the unimpaired and reconfigured AFTI/F-16 aircraft longitudinal responses in the presence of atmospheric turbulence and sensor noise is made. Author

A90-49113#**OBTAINING PRECISE LTR WITH LUENBERGER TYPE OBSERVER WITH ARBITRARY OBSERVER POLES AND FINITE GAIN**

J. B. BARLOW, I. O. PANDELIDIS (Maryland, University, College Park), and M. M. MONAHEMI AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p. refs

(AIAA PAPER 90-3228) Copyright

An investigation has been made of the application of robust reduced order observer theory to the design of flight control systems for advanced aircraft configurations. The design has precise loop-transfer recovery (LTR) with arbitrary observer poles and finite observer gain. It is shown that for an arbitrary regulator feedback gain (K_c) of an observable plant with more measurements than controls, the corresponding regulator loop transfer function can be precisely recovered by a Luenberger (1971) type observer with arbitrary stable poles and finite gain observer (K_f). This paper also shows that this approach guarantees the observer stability for nonminimum phase systems. This procedure actually achieves the theoretical achievable LTR result and significantly improves the results of existing LTR procedures of Kilman filters which do not have the freedom of filter eigenstructure assignment. Case studies for the design of flight controls systems are presented. Author

N90-26833# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.

THE ROLE OF $C(\text{SUB } n \text{ BETA.DYN})$ IN THE AIRCRAFT STABILITY AT HIGH ANGLES OF ATTACK

ZHIDAI HE 30 Mar. 1990 16 p Transl. into ENGLISH from Hangkong Xuebao (Peoples Republic of China), v. 9, no. 10, 1988 p B462-B468

(AD-A221586; FTD-ID(RS)T-1187-89) Avail: NTIS HC A03/MF A01 CSCL 01/1

Concrete examples of calculations are used to analyze the reliability of $C(\text{sub } n \text{ beta.dyn})$ as a stability criterion at high angles of attack, and deductions are made regarding the errors that may result from the use of this criterion. Results were obtained that will be of value in the use of this criterion. GRA

N90-26834# Aeritalia S.p.A., Turin (Italy). Gruppo Aerei da Difesa.

NEW INFLIGHT EXPERIMENTS TO MEASURE AERODYNAMICS LOADS [NUOVE ESPERIENZE NEL RILIEVO IN VOLO DI CARICHI AERODINAMICI]

P. DURANTI and B. BELLATI 1989 12 p In ITALIAN Presented at the 10th Congresso Nazionale, Pisa, Italy, 16-19 Oct. 1989 (ETN-90-97276) - Avail: NTIS HC A03/MF A01

The flight load survey experience gained in the tornado and AMX aircraft programs is described. The accuracy and cost of the extensometric procedures is analyzed. They are based on

multiple solid state microtransducers distributed on the active surfaces. The new methodology is more accurate and reliable, and has thus been adopted. ESA

N90-27625# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).

START-UP BUILT-IN TEST FOR THE DISCUS FAULT TOLERANT, FLY-BY-WIRE COMPUTER SYSTEM

R. SUDDUTH *In its Aircraft Integrated Monitoring Systems* p 163-184 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The work carried out to implement built-in test on the Digital Self-healing Control for Upgraded Safety (DISCOUS) system is presented. The use of built-in test procedures are discussed as they apply to the DISCUS fault tolerant, fly-by-wire computer system. The stringent reliability requirements placed on flight critical components forces the use of redundant computer systems to decrease the possibility of total loss of the aircraft. The probability of total loss by utilizing built-in test techniques is decreased.

ESA

N90-27724# Systems Technology, Inc., Hawthorne, CA. FLIGHT TEST INVESTIGATION OF FLIGHT DIRECTOR AND AUTOPILOT FUNCTIONS FOR HELICOPTER DECELERATING INSTRUMENT APPROACHES

ROGER H. HOH, STEWART BAILLIE, and STAN KERELIUK Nov. 1989 50 p Prepared in cooperation with Systems Control Technology, Inc., Arlington, VA (Contract DTFA01-87-C-00014)

(DOT/FAA/CT-TN89/54) Avail: NTIS HC A03/MF A01

An in-flight experiment was conducted to evaluate certification factors for decelerating approaches for rotary wing aircraft in instrument meteorological conditions (IMC). The goals of the experiment were to determine: (1) limiting factors for crosswind regulation; (2) acceptable combinations of flight director and autopilot functions; and (3) necessary characteristics for the collective flight director. It was found that both the wing-low, and the turn-coordination (crab) methods of crosswind regulation were acceptable for approaches down to 50 feet altitude and 25 knots ground speed. It was also found to be acceptable blend from the crabbed approach during the deceleration. The experiment only considered the ICM portion of the approach so that field of view at breakout considerations should not be factored into results of this study. Acceptable performance and pilot workload was achieved with a two axis flight director (pitch and roll), and raw data collective, as well as all of the more sophisticated configurations. Raw data approaches (no flight director) were found to be unacceptable. The augmentation consisted of low gain rate damping for all of the tested configurations. Author

N90-27725# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ACTIVE CONTROL OF AEROTHERMOELASTIC EFFECTS FOR A CONCEPTUAL HYPERSONIC AIRCRAFT

JENNIFER HEEG, MICHAEL G. GILBERT, and ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA.) Aug. 1990 12 p Presented at the AIAA Guidance, Navigation and Control Conference, Portland, OR, 20-22 Aug. 1990

(NASA-TM-102713; NAS 1.15:102713) Avail: NTIS HC A03/MF A01 CSCL 01/3

Procedures for and results of aeroservoelastoc studies are described. The objectives of these studies were to develop the necessary procedures for performing an aerolastic analysis of an aerodynamically heated vehicle and to analyze a configuration in the classical cold state and in a hot state. Major tasks include the development of the structural and aerodynamic models, open loop analyses, design of active control laws for improving dynamic responses and analyses of the closed loop vehicles. The analyses performed focused on flutter speed calculations, short period eigenvalue trends and statistical analyses of the vehicle response

to controls and turbulence. Improving the ride quality of the vehicle and raising the flutter boundary of the aerodynamically-heated vehicle up to that of the cold vehicle were the objectives of the control law design investigations. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A90-45888#

STATIC AND DYNAMIC WATER TUNNEL TESTS OF SLENDER WINGS AND WING-BODY CONFIGURATIONS AT EXTREME ANGLES OF ATTACK

DAVID MANOR (Saint Louis University, MO), LEONARD MILLER, and WILLIAM H. WENTZ, JR. (Wichita State University, KS) IN: AIAA Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 474-482. refs (AIAA PAPER 90-3021) Copyright

A series of sharp-edge delta wings, wing-bodies, and a complete fighter aircraft configuration (SU-27) were tested at Wichita State University's 2 ft x 3 ft water tunnel. The tests were performed under static and dynamic conditions up to 110-deg angle of attack. The effects of nondimensional pitch rate on vortical flow field behavior were recorded using a video camera. The results show that burst lag, for both the wing and wing-body configurations, is increased as pitch rate is increased. Addition of a body has a minimal effect on vortex burst location under static conditions. Flow behavior for the complete aircraft was similar to the wing-body models examined. Author

A90-46537

EFFECT OF A CRESCENT-SHAPED RIGID SUPPORT ON THE AERODYNAMIC CHARACTERISTICS OF MODELS IN THE PRESENCE OF PERFORATED BOUNDARIES [VLIANIE SERPOVIDNOI ZHESTKOI STOIKI NA AERODINAMICHESKIE KHARAKTERISTIKI MODELEI V PRISUTSTVII PERFORIROVANNYKH GRANITS]

A. V. PILIUGIN, O. K. SEMENOVA, and O. IU. STARIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989, p. 46-52. In Russian. refs

Copyright

Based on a solution to the three-dimensional linear boundary value problem in the context of the small perturbation theory, an analytical method is proposed for finding corrections for the aerodynamic characteristics of models associated with the effect of a crescent-shaped rigid support in the presence of perforated flow boundaries. The effective applicability boundaries of the method proposed here are determined by the range of regimes of nonseparated flow past models characterized by small values of angles of attack and slp. V.L.

A90-46576

CHARACTERISTICS OF TEMPERATURE AND PRESSURE GENERATION AND RETENTION IN FLOW INSIDE CRYOGENIC WIND TUNNEL T-04 [OSOBENNOSTI USTANOVLENIIA I PODDERZHANIIA TEMPERATURY I DAVLENIIA V POTOKE KRIOGENNOI AERODINAMICHESKOI TRUBY T-04]

S. IU. BORISOV, A. L. ISKRA, and A. M. NAUMOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 6, 1989, p. 105-109. In Russian. refs

Copyright

Results of experiments concerned with the measurement of flow pressure and temperature in a cryogenic wind tunnel with an ejector drive are presented for different operating modes. It is shown that

the cold regeneration system makes it possible to maintain a uniform flow temperature field at temperatures above 100 K. A comparative analysis of flow characteristics is carried out for wind operation at normal and cryogenic temperatures. V.L.

A90-48956#

MODELING OF TURBULENCE AND DOWNBURSTS FOR FLIGHT SIMULATORS

LLOYD D. REID (Toronto, University, Canada) and PAUL A. ROBINSON Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 700-707. Research supported by NSERC. Previously cited in issue 21, p. 3277, Accession no. A89-48396. refs Copyright

A90-48960#

STEREOPSIS AS A VISUAL CUE IN FLIGHT SIMULATION

REED P. TIDWELL (Evans and Sutherland, Salt Lake City, UT) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 731, 732.

Copyright

Stereopsis is different from most visual cues to depth in that it is physiological rather than psychological. An account is given of how stereopsis may be incorporated into the 'out-the-window' visual system incorporated by flight simulators, with attention to the results obtained by experiments using collimated imagery to relax the accommodation-convergence restrictions of directly viewed CRTs. Advancements in computer image generation make possible the routine incorporation of stereoscopic out-the-window imagery in flight simulations. O.C.

A90-48961*# Tennessee Univ. Space Inst., Tullahoma.

COMPARISONS OF ONE- AND TWO- INTERFACE METHODS FOR TUNNEL WALL INTERFERENCE CALCULATION

C. F. LO and N. ULBRICH (Tennessee, University, Tullahoma) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 732-735. Research supported by the University of Tennessee. refs (Contract NAG2-551)

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Tunnel wall interference in two-dimensional subsonic flow can be analytically calculated on the basis of the one- or two-interface method. The application of numerical integration by means of matrix multiplication to both methods has been found to significantly reduce CPU time in on-line operation. An investigation of the sensitivity of these methods to random velocity-measurement disturbances shows the one-interface method to be less sensitive to measurement errors, and therefore to be preferable for practical applications. O.C.

A90-49273

EFFECTS OF TRANSITION ON WIND TUNNEL SIMULATION OF VEHICLE DYNAMICS

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 27, no. 2, 1990, p. 121-144. refs

Copyright

Among the many problems the test engineer faces when trying to simulate full-scale vehicle dynamics in a wind tunnel test is the fact that the test usually will be performed at Reynolds numbers far below those existing on the full-scale vehicle. It is found that a severe scaling problem may exist even in the case of attached flow. The strong coupling existing between boundary layer transition and vehicle motion can cause the wind tunnel results to be very misleading, in some cases dangerously so. For example, the subscale test could fail to show a dynamic stability problem existing in full-scale flight, or, conversely, show one that does not exist. When flow separation occurs together with boundary layer transition, the scaling problem becomes more complicated, and the potential for dangerously misleading subscale test results increases. The existing literature is reviewed to provide examples of the different types of dynamic simulation problems that the test engineer is likely to face. It should be emphasized that the difficulties presented by transition effects in the case of wind tunnel

simulation of vehicle dynamics apply to the same extent to numeric simulation methods. Author

N90-26835# Federal Aviation Administration, Atlantic City, NJ.

ATLANTA TOWER SIMULATION, VOLUME 1

LLOYD HITCHOCK, LEE E. PAUL, EPHRAIM SHOCHET, and RICHARD D. ALGEO Nov. 1989 82 p

(Contract F2006C)

(DOT/FAA/CT-TN89/27-VOL-1) Avail: NTIS HC A05/MF A01

At the request of the Atlanta (ATL) Facility, the Technical Center conducted dynamic real-time simulations of selected aspects of the Atlanta Tower's Airport Enhancement Plan. Atlanta controllers, who served as subjects, evaluated traffic flow to a three runway configuration with both a third parallel runway, 3000 feet south of existing runway 9R and a 30 degree converging runway. Large numbers of blunders (deviations of inbound aircraft away from their assigned localizer paths) were introduced to exercise the proposed system. In over 90 blunders during approaches to the third parallel runway, 5 resulted in closure distances between aircraft small enough to merit detailed analysis. The smallest horizontal distance involved 30 degree blunders across the 3000-foot separation with four of these also simulating a complete loss of communications. The overall simulation results demonstrated the controllers' ability to maintain an orderly flow of traffic to both the triple parallel and converging runway configurations. When repeatedly challenged by the unlikely combination of 30 degree NORDO blunders, 94 percent were managed without incident. The decision on runway separation distances for new construction of runways in Atlanta should not be based solely on the results of this simulation. Additional relevant data is now available which could affect the results, including navigation data from Chicago O'Hare, and automation and radar data being collected at Memphis, TN and Raleigh-Durham, NC. Potential capacity restraints are possible based on a combination of flight technical error around the localizer and a normal operating zone reduced to 500 feet. There are a number of ongoing technological innovations to be considered, as well as associated automation features, which are being tested by the high update radar sensors at Raleigh-Durham and Memphis. Author

N90-26836# Federal Aviation Administration, Atlantic City, NJ.

ATLANTA TOWER SIMULATION, VOLUME 2: APPENDIXES

LLOYD HITCHOCK, LEE E. PAUL, EPHRAIM SHOCHET, and RICHARD D. ALGEO Nov. 1989 267 p

(Contract F2006C)

(DOT/FAA/CT-TN89/27-VOL-2) Avail: NTIS HC A12/MF A02

Appendixes for the Atlanta Tower simulation, a series of real-time simulations of selected aspects of the Atlanta Tower's Airport Enhancement Plan, are given. Data on traffic flow to a three runway configuration with a third runway 3000 feet south of existing runway 9R and a 30 degree converging runway is given in chart and tabular form. Author

N90-26838# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.

FLUID DYNAMICS PANEL WORKING GROUP 12 ON

ADAPTIVE WIND TUNNEL WALLS: TECHNOLOGY AND APPLICATIONS

Apr. 1990 153 p

(AGARD-AR-269; ISBN-92-835-0558-1; AD-A223937) Copyright

Avail: NTIS HC A08/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The results of a study by Working Group 12 of the Fluid Dynamics Panel of AGARD on adaptive-wall wind tunnels are presented. The history and state of the art of adaptive-wall technology are reviewed with regard to both the various streamlining algorithms and the existing adaptive-wall facilities; limitations and open questions of adaptive-wall methods are discussed and compared with passive-wall correction techniques; residual wall interferences are assessed; the prospects are presented for high-productivity and unsteady flow testing with adaptive walls; and recommendations are made for future developments.

N90-26839# Southampton Univ. (England).

THE AIMS AND HISTORY OF ADAPTIVE WALL WIND TUNNELS

MICHAEL J. GOODYER, ed., J. P. CHEVALLIER, J. C. ERICKSON, JR., M. C. LEWIS, PETER B. S. LISSAMAN, H. H. PEARCEY, E. W. E. ROGERS, and W. F. HILTON (National Physical Lab., Teddington, England) / In AGARD, Fluid Dynamics Panel Working Group 12 on Adaptive Wind Tunnel Walls: Technology and Applications p 1-7 Apr. 1990

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The adaptive wall test section has its roots in the area when flight speeds were beginning to approach transonic on the level or in dives, that is the 1930s. The object of this historical review is to place on record the more important steps in the evolution of the adaptive wall test section in its various forms from these early times up to about 1975 when the first examples of all of the modern varieties were well on their way. Author

N90-26840*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FACILITIES INVOLVED IN ADAPTIVE WALL RESEARCH

CHARLES L. LADSON, ed. / In AGARD, Fluid Dynamics Panel Working Group 12 on Adaptive Wind Tunnel Walls: Technology and Applications p 8-20 Apr. 1990

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During the first meeting of the Working Group, it was apparent that the assessment and interpretation of the current level of the technology could be achieved most easily provided the information in a common format. This would also minimize any danger of misinterpretation by third parties of existing published information. As a result, the Group developed a questionnaire and distributed it to all involved in adaptive wall research. The questionnaire solicited information on the mechanical details of the facilities as well as details of the adaptation strategy itself. The scope of testing accomplished and future plans were included. The information contained in the responses is summarized. This information was the source for much of the data. Because some of the data contained in these questionnaires is not discussed elsewhere, they are reproduced in their entirety as an Appendix. The questionnaire is also presented to serve as a guide to the written responses. Author

N90-26843# National Aerospace Lab., Amsterdam (Netherlands).

HIGH PRODUCTIVITY TESTING

J. SMITH, ed., ERICH H. WEDEMEYER, and ANDRE MIGNOSI (Centre d'Etudes et de Recherches, Toulouse, France) / In AGARD, Fluid Dynamics Panel Working Group 12 on Adaptive Wind Tunnel Walls: Technology and Applications p 59-65 Apr. 1990.

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Considering investment cost, running cost, operational versatility and flow quality, the present feeling is that a two-dimensional flexible wall test section is a near-optimum solution for production windtunnels, up to high subsonic Mach numbers. For near-sonic test conditions, ventilated walls are still unrivalled. High productivity implies the requirement of continuous testing, i.e., performing measurements while the test conditions are gradually, but continuously, varying in a controlled way. One Step Methods are not by themselves suited for continuous testing. In order to anticipate the ever varying test conditions, the necessary wall adaptation strategy must also to some extent be predictive. Such strategies are presently not well established. Therefore a possible high productivity strategy has been discussed in a somewhat speculative fashion, although supported by a little experimental and numerical evidence. Author

N90-26844*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LIMITS OF ADAPTATION, RESIDUAL INTERFERENCES

MIROSLAV MOKRY, ed., J. C. ERICKSON, JR., MICHAEL J. GOODYER, ANDRE MIGNOSI, GIUSEPPE P. RUSSO, J. SMITH, ERICH H. WEDEMEYER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.), and PERRY A. NEWMAN / In AGARD, Fluid Dynamics Panel Working Group 12 on Adaptive Wind Tunnel Walls: Technology and Applications p 66-90 Apr. 1990

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Methods of determining linear residual wall interference appear to be well established theoretically; however they need to be validated, for example by comparative studies of test data on the same model in different adaptive-wall wind tunnels as well as in passive, ventilated-wall tunnels. The GARTEUR CAST 7 and the CAST 10/DOA 2 investigations are excellent examples of such comparative studies. Results to date in both one-variable and two-variable methods for nonlinear wall interference indicate that a great deal more research and validation are required. The status in 2D flow is advanced over that in 3D flow as is the case generally with adaptive-wall development. Nevertheless, it is now well established that for transonic testing with extensive supercritical flow present, significant wall interference is likely to exist in conventional ventilated test sections. Consequently, residual correction procedures require further development hand-in-hand with further adaptive-wall development. Author

N90-26845# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).

ADAPTATION FOR UNSTEADY FLOW

HANS W. FOERSCHING, ed. and R. VOSS / In AGARD, Fluid Dynamics Panel Working Group 12 on Adaptive Wind Tunnel Walls: Technology and Applications p 91-99 Apr. 1990

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Wind tunnel wall interference in unsteady flow has not been as thoroughly investigated as in steady flow. In the case of unsteady flow the wind tunnel wall interference problem is much more complicated by additional parameters describing the time-dependent variation of the unsteady flow field. With the recent development of adaptive wind tunnel walls, by which steady wall effects are eliminated or significantly reduced by actively controlling flow near the walls, new possibilities for correction of wind tunnel wall interference have also emerged for unsteady flow. Prospects and concepts of experimental and analytical techniques for correction of unsteady wind tunnel wall effects, appearing with aerodynamic and aeroelastic measurements of oscillating lifting systems and bodies, are presented. First, some fundamental relations of motion-induced unsteady flow fields, basic to a physical understanding and analytical treatment of unsteady flow phenomena, are explained. Then the principal causes of unsteady wind tunnel interference are described and the practicability of adaptive wind tunnel walls to eliminate unsteady aerodynamic wall interference effects in unsteady aerodynamic and aeroelastic wind tunnel model measurements is discussed. Finally prospective wind tunnel wall corrections for motion-induced unsteady flow, applying steady flow wall adaptation and CFD-techniques, are outlined. Author

N90-26847# Royal Aerospace Establishment, Bedford (England).

THE NEED FOR PLATFORM MOTION IN MODERN PILOTED FLIGHT TRAINING SIMULATORS

J. R. HALL Oct. 1989 19 p
(AD-A221720; RAE-TM-FM-35; DRIC-BR-113553) Avail: NTIS HC A03/MF A01 CSCL 05/9

This paper discusses motion cueing in piloted flight training simulators, and presents the factors that must be taken into account when assessing the need for, and benefits of, a motion platform

09 RESEARCH AND SUPPORT FACILITIES (AIR)

so that informed decisions can be taken as to its training value. These factors include the role of the simulator, the handling qualities of the vehicle concerned, the tasks the pilot is required to fly, the performance he is expected to achieve and whether training considerations require him to use a similar control strategy and control activity in the simulator as in the aircraft. GRA

N90-27633# Japan Air Lines Co. Ltd., Tokyo.

NEW FEATURES OF JAL'S GROUND STATION

F. NAGAMATSU /in DLR, Aircraft Integrated Monitoring Systems p 333-350 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Japan Airlines (JAL) installed new ground stations at Narita and Haneda Airports in December 1988. These two stations are connected with a high speed data communication line. The response time to the Aircraft Integrated Monitoring Systems (AIMS) data is improved. The issue of long transcription time of increasing numbers of cassette tapes is resolved. The structure and new features of this system and the future plans for a total data system are outlined. ESA

N90-27728# Illinois Univ., Urbana. Dept. of Civil Engineering.

AIRPORT PAVEMENT DRAINAGE

JEANETTE A. HARE, RICHARD A. PUR, and BARRY J. DEMPSEY Jun. 1990 96 p

(DOT/FAA/RD-90/24) Avail: NTIS HC A05/MF A01

A literature review of the state-of-the-art for airport drainage is provided. The literature is reviewed concerning the climatic parameters which relate to airport drainage. A summary of the past practices for both surface and subsurface drainage for airports is provided which describes drainage structures and design procedures. The components of a subsurface drainage system which are applicable to airports are described. Author

N90-27729# Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction de la Physique Generale.

TESTS OF AN ULTRA-LIGHT TUNNEL IN THE ANECHOIC

WIND TUNNEL FACILITY CEPRA 19 Final Report [ESSAI

D'UN TUNNEL ULTRA-LEGER DANS LA SOUFFLERIE

ANECHOIQUE CEPRA 19, RAPPORT FINAL]

S. LEWY, J. LAMBOURION, and G. RAHIER Jul. 1988 59 p In FRENCH Sponsored by Direction des Recherches, Etudes et Techniques, Paris, France

(ONERA-RF-20/7294-PH; ETN-90-97496) Avail: NTIS HC A04/MF A01

The ultra-light tunnel consists of a casing of sound conducting material, designed to transform a free jet in a guided flow. It can be applied in anechoic wind tunnel for improving aerodynamic capabilities without lowering the measurements of the noise of the long distance field. The tests performed from Jan. to Feb. are reported. The mechanical properties of the system is satisfactory. The sound transmission is acceptable up to 4 kHz. Applications fields of the research program are emphasized. ESA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A90-46397#

TIME SYNCHRONIZATION/DISTRIBUTION APPLICATIONS OF NAVIGATION SIGNALS REPEATED BY GEOSTATIONARY SATELLITES

GEORGE KINAL (INMARSAT, London, England) and SIEGFRIED STARKER (DLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, Federal Republic of Germany) IN: Radio Technical Commission for Aeronautics, Annual Assembly and Technical Symposium, Washington, DC, Dec. 4-6, 1989, Proceedings. Washington, DC, Radio Technical Commission for Aeronautics, 1989, p. 157-165.

Advantages and applications of geostationary satellites for time transfer are outlined, including the advantages of a continuous independent reference and the availability of accurate frequency for future communications and avionics systems. It is demonstrated that once the resources for a spread spectrum GPS (or GLONASS) integrity channel are utilized, a small upgrade can be done in order to allow the same signal to be used for pseudorange; these additions are comparable to those required for a time-reference service. A typical navigation receiver is compared with a receiver designed for reception of the Inmarsat geostationary overlay signal, and experimental results from the Inmarsat test bed are presented and analyzed. It is concluded that the Inmarsat geostationary overlay can be used as an accurate time and frequency standard for worldwide users. V.T.

A90-46484

MULTIPLE-STEP TERMINAL CONTROL WITH PARAMETER IDENTIFICATION AND PREDICTION DURING FLIGHT

VEHICLE DESCENT [MNOGOSHAGOVoe TERMINAL'NOE

UPRAVLENIE S IDENTIFIKATSEI I PROGNOZOM

PARAMETROV PRI SPUSKE LETATEL'NOGO APPARATA]

T. K. SIRAZETDINOV and V. I. KISELEV Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 24-28. In Russian.

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A method is presented for multiple-step terminal control at a section of the glide path of a flight vehicle in the dense layers of the atmosphere. In accordance with the method, the parameters are identified and predicted at each step of the control process. Results of a computer simulation of the motion of a flight vehicle are presented. V.L.

A90-47587#

STRUCTURE/CONTROL DESIGN SYNTHESIS OF ACTIVE FLUTTER SUPPRESSION SYSTEM BY GOAL PROGRAMMING

S. SUZUKI (Tokyo, University, Japan) and S. MATSUDA IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 96-104. refs

(AIAA PAPER 90-3325) Copyright

The simultaneous design of the structure and control for a typical wing section with a trailing control surface is considered. Since the original structure usually has inadequate dynamic characteristics for active control, design parameters must be optimally modified. Full-state feedback control gains are designed using the linear-quadratic-Gaussian regulator theory at the design airspeed, thus this is the only control design parameter. A typical wing section with a trailing control surface is examined as a design example, and then both structure and control design parameters are optimized in accordance with the following prioritized design requirements: (1) the flutter speed of an initial open-loop system is maintained; (2) the stability characteristics of a closed-loop system are obtained over a wide range of flight speed; (3) the control-surface deflection angle is restrained; and (4) the degree of structural design changes is minimized. The sequential goal programming method is successfully applied to optimize these multidisciplinary design requirements. Author

A90-49120*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CFD SUPPORT OF NASP DESIGN

CHARLES R. MCCLINTON (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 22 p. refs

(AIAA PAPER 90-3252) Copyright

This paper presents a summary of design studies from the 'open' literature which illustrate the level of effort and the use of computational fluid dynamics (CFD) to support the National Aerospace Plane (NASP) X-30 design. CFD plays a major role in the NASP program, particularly for the very high speed regions (Mach greater than 10) where wind tunnels cannot fully simulate the flow and/or flow-field measurements are difficult to obtain. Full simulation (nose-to-tail analysis) of the NASP flow field, both internal and external, is discussed. Author

A90-49671

THE RADARSAT SYSTEM

S. AHMED, H. R. WARREN (Canadian Space Agency, Radarsat Project Technical Office, Ottawa, Canada), M. D. SYMONDS, and R. P. COX (Spar Aerospace, Ltd., Sainte-Anne-de-Bellevue, Canada) (IEEE, Canadian Remote Sensing Society, URSI, et al., Quantitative remote sensing: An economic tool for the Nineties - 1989 International Geoscience and Remote Sensing Symposium and Canadian Symposium on Remote Sensing, 12th, (IGARSS'89), Vancouver, Canada, July 10-14, 1989) IEEE Transactions on Geoscience and Remote Sensing (ISSN 0196-2892), vol. 28, July 1990, p. 598-602.

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Radarsat, a remote-sensing satellite with a SAR sensor, is discussed. The spacecraft is scheduled for launch into a sun-synchronous dawn-dusk polar orbit in 1994. The mean orbit altitude and inclination are 789 km and 98.6 deg, respectively. The right-looking SAR, with the unique ability to shape and steer the radar beam over a 500-km accessibility swath, will provide daily Arctic coverage, coverage of the Canadian land mass every 3 days, and coverage of the globe every 24 days. A wide variety of swath widths, incidence angles, and resolutions can be selected. The SAR can also be oriented to the left of the flight path to enable coverage of central Antarctica. The objective of the Radarsat program is to gather data of both applications and research value related to global ice, oceans, and renewable and nonrenewable resources. The spacecraft will have the ability to store instrument data that can later be transmitted to an appropriate data-acquisition station, thus ensuring global coverage. I.E.

A90-49763

BATTERY CONFIGURATIONS FOR MULTI-MEGAWATT PULSE POWER

HENRY OMAN (Boeing Aerospace, Seattle, WA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 5, Aug. 1990, p. 23-26. refs

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The capability of lead-acid batteries for supplying very high power for a short time is explored. The application of such a battery for accelerating a hypersonic plane is used to illustrate the requirements. A technique for analyzing batteries and controlling voltage for pulse loads is described. Evaluation of lead-acid batteries in production and voltage regulation by switching batteries in and out are covered. Alternatives to batteries, including superconducting magnetic energy storage, are discussed. I.E.

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A90-46496

DESIGN OF THE OPTIMAL HARDENING TREATMENT FOR THE METAL SURFACES OF GAS TURBINE ENGINE COMPONENTS [PROEKTIROVANIE OPTIMAL'NOI UPROCHNIAUSHCHEI OBRABOTKI METALLICHESKIKH POVERKHNOSTEI DETALEI GTD]

S. M. BOROVSKII and V. S. MUKHIN Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 70-74. In Russian. refs Copyright

The possibilities offered by the finite element approach to the modeling of the optimum (with respect to maximum load-bearing capacity) plastic surface working of metal materials are examined with particular reference to the surface treatment of gas turbine components. The problem is solved using a relaxation scheme of plastic working, with the strength limit of the interatomic bonds used as the criterion of surface optimality. The approach proposed here is illustrated by results obtained for VT-9 titanium alloy. V.L.

A90-46514

CYCLIC FRACTURE TOUGHNESS OF VT3-1 AND VT-25 TITANIUM ALLOYS [TSIKLICHESKAIA TRESHCHINOSTOIKOST' TITANOVYKH SPLAVOV VT3-1 I VT-25]

IU. G. BYKOV, A. N. PETUKHOV, and S. A. CHERKASOVA Fiziko-Khimicheskaya Mekhanika Materialov (ISSN 0430-6252), vol. 26, May-June 1990, p. 49-53. In Russian. refs Copyright

Fatigue crack growth rates were determined experimentally in 50x50x10-mm compact specimens cut out of the compressor disks of aviation gas turbine engines. The crack growth was monitored by optical, ultrasonic, and acoustic emission methods, and fracture surfaces were studied by electron microscopy. The fractographic studies, aimed at estimating the microscopic crack growth rates from the fatigue striation pitch, have confirmed that the crack growth rates are higher in the VT-25 alloy. The results obtained have made it possible to estimate the lives of compressor disks of VT3-1 and VT-25 alloys and can be used for scheduling nondestructive inspection of gas turbine engines. V.L.

A90-46525

INTERCHANGEABILITY OF SOVIET-MADE AND FOREIGN MINERAL OILS FOR AVIATION GAS TURBINE ENGINES [VZAIMOZAMENIAEMOST' OTECHESTVENNYKH I ZARUBEZHNYKH MINERAL'NYKH MASEL DLIA AVIATSIONNYKH GAZOTURBINNYKH DVIGATELEI]

V. V. GORIACHEV, O. A. ZAPOROZHSKAIA, E. N. CHVYKOVA, E. M. SHITOVA, and L. P. ARKHAROVA (Tsentr'nyi Nauchno-Issledovatel'skii Institut Aviatzionnogo Motorostroeniia; Vsesoiuznyi Nauchno-Issledovatel'skii Institut Aviatzionnogo Materialovedeniia, Moscow, USSR) Khimiia i Tekhnologiya Topliv i Masel (ISSN 0023-1169), no. 7, 1990, p. 13-15. In Russian. Copyright

The properties of some commonly used gas turbine oils manufactured in different countries, are examined to determine whether they meet the requirements of the Soviet standards, with a view to ensuring the operation safety of exported Soviet aircraft. In particular, attention is given to such oil characteristics as thermal stability, lubricating capacity, and compatibility with sealer materials. Of the oils tested, oils HP-8 and AVI-8A, manufactured by China and Rumania, respectively are found to be fully compatible with the Soviet-made oils MK-8, MK-8p, and MS-8p. V.L.

A90-46882#

COMBUSTION PROCESS IN A GAS TURBINE COMBUSTOR WHEN USING H₂, NH₃ AND LPG FUELS

A. A. DESOKY, A. S. KHALAF, and F. M. EL-MAHALLAWY (Mansoura University, Egypt) IN: International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 2. Mansoura, Egypt, Mansoura University, 1990, p. 797-808. refs

Combustion characteristics of gaseous hydrogen fuel in a can type gas turbine combustor are presented. Combustion performance of hydrogen is compared with that of ammonia and liquefied petroleum gaseous fuels using the same combustion hardware. The experiments have been directed to study the influence of the swirling angle of the primary air, secondary air ratio and equivalence ratio on combustion performance. Four different swirl angles namely, 0, 32, 52 and 72 degrees are used. The secondary air ratios are varied from 10 to 50 percent from

the total air supplied. Results obtained are similar for all fuels used. Changes in primary air swirl angle, equivalence ratio, and secondary air ratios cause significant changes in combustion performance. Hydrogen combustion is characterized by high combustion efficiency, ease of ignition, and good flame stability. However, it can also result in relatively high metal temperature which can impact on liner durability and high NOx emissions.

Author

A90-48131* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PERFORMANCE EVALUATIONS OF OXIDATION-RESISTANT CARBON-CARBON COMPOSITES IN SIMULATED HYPERSONIC VEHICLE ENVIRONMENTS

D. M. BARRETT, H. G. MAAHS, C. W. OHLHORST (NASA, Langley Research Center, Hampton, VA), W. L. VAUGHN (Planning Research Corp., Hampton, VA), and R. H. MARTIN (National Research Council, Hampton, VA) IN: Symposium on High Temperature Composites - Proceedings of the American Society for Composites, Dayton, OH, June 13-15, 1989. Lancaster, PA, Technomic Publishing Co., Inc., 1989, p. 282-297. refs

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An evaluation is made of the oxidation-protection requirements of carbon-carbon composite (CCC) structural components in a hypersonic vehicle aerothermodynamic environment, where maximum test temperatures in air are of the order of 2800 F, and pressures range from 0.03 to 1.0 atm. The specimens were exposed to high humidity between tests. Attention was given to the effects of coating composition and thickness, and of substrate architecture and surface preparation, on the oxidation resistance of CCCs. Both surface preparation and coating chemistry have a profound effect on coating adherence and longevity. O.C.

A90-48993

COMPOSITE FLIGHT CONTROL ACTUATORS

Aerospace Engineering (ISSN 0736-2536), vol. 10, Sept. 1990, p. 17-19.

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Some of the research on developing ways of making flight control actuators more survivable for combat aircraft is directed at developing composite actuators. In addition to being lighter, composite actuators may realize some important combat aircraft survivability needs. Jam resistant features of these actuators has been confirmed by ballistic testing. The end gland that forms the closure of the cylinder's open end is a relatively low-stress part and thus permits the use of an injection-molded thermoplastic polyetheretherketone (PEEK) material. This PEEK end gland has passed temperature, burst pressure, and proof pressure shock tests, and withstood two million impulse cycles and one and a half million life cycles. One such modular composite actuator, with the addition of other composite parts, resulted in a weight reduction of 47 percent when compared to a similarly designed metal actuator. R.E.P.

A90-48997

METAL LAMINATES FOR AEROSPACE APPLICATIONS

MARC VERBRUGGEN (Akzo Coatings, Arnhem, Netherlands) Metals and Materials (ISSN 0266-7185), vol. 6, Aug. 1990, p. 493-495.

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A relatively new class of materials developed for the aerospace industry offers weight-savings, damage tolerance and fatigue sensitivity. Composite laminates combine reinforcing fibers, adhesives and metals. This article discusses the development, properties and potential applications of these materials. Author

A90-49000

TITANIUM ALUMINIDES FOR ADVANCED AIRCRAFT ENGINES

J. C. CHESNUTT and J. C. WILLIAMS (GE Aircraft Engines, Cincinnati, OH) Metals and Materials (ISSN 0266-7185), vol. 6, Aug. 1990, p. 509-511.

Copyright

The U.S. aircraft industry owes much of its success to the steady improvements in thrust and in fuel consumption of aircraft engines. The search to further improve specific thrust, both for the integrated high performance turbine engine technology and National Aerospace Plane programs in the U.S. and similar programs abroad, has lead to extensive work on titanium aluminides over the last five years. This article reviews the progress made in developing these alloys and outlines the author's view of their potential for advanced engine applications. Author

N90-26887# Army Materials Technology Lab., Watertown, MA. Polymer Research Branch.

APPLICATIONS OF DIGITAL IMAGE PROCESSING IN TESTING AND EVALUATION OF COMPOSITE MATERIALS Final Report

GARY L. HAGNAUER, JAMES D. KLEINMEYER, JOHN J. WIXTED, and JOHN H. GRUBBS (Military Academy, West Point, NY.) May 1990 21 p

(Contract DA PROJ. 1L1-62105-AH-84)

(AD-A222939; MTL-TR-90-24) Avail: NTIS HC A03/MF A01

CSCL 11/4

This report describes the development and application of digital image processing techniques for analyzing the fracture behavior and environmental deterioration of test specimens prepared from composite laminate materials used in the manufacture of helicopter rotor blades. The digitized images were evaluated using pixel histograms generated through routines developed on a C-interpretor. Laminate fiber orientation and aging conditions were found to have a significant effect on the observed fracture patterns and surface characteristics of the test specimens. Pixel histograms of environmentally aged test specimens were broader and shifted to higher grey level values compared to histograms of the unaged specimens. Under the test procedures developed, digital image analysis results were reproducible and fiber orientation did not significantly affect the average grey level of either aged or unaged specimens. GRA

N90-26894# Costruzioni Aeronautiche Giovanni Agusta S.p.A., Cascina Costa (Italy). Div. Elicotteri.

DESIGN OF HELICOPTER COMPONENTS IN METAL MATRIX COMPOSITES [CONSIDERAZIONI SULLA PROGETTAZIONE DI COMPONENTI PER ELICOTTERO IN COMPOSITI A MATRICE METALLICA]

FRANCO PERSIANI, GIAN PAOLO CAMMAROTA (Bologna Univ., Italy), and GIANCARLO DONZELLI 16 Oct. 1989 19 p IN ITALIAN

(REPT-100-20-55; ETN-90-97268) Avail: NTIS HC A03/MF A01

The general criteria to identify the components suitable to be manufactured with metal matrix composites are discussed. The technological analysis of the possible contribution of these materials to helicopter design is presented. The status of research activities in this field is discussed. ESA

N90-26902# Vanderbilt Univ., Nashville, TN. Dept. of Mechanical and Materials Engineering.

RAMAN SCATTERING MEASUREMENTS USING UV EXCIMER LASERS

ROBERT W. PITZ, JOSEPH A. WEHRMEYER, and JOHN M. BOWLING In Sandia National Labs., Summary of Discussions at the Eleventh Meeting of the Sandia Cooperative Group on the Aerothermochemistry of Turbulent Combustion p 24-33 Oct. 1988

Avail: NTIS HC A03/MF A01

Efficient mixing and combustion are critical issues for practical supersonic combustion. Due to the lack of data in supersonic combustion, little is known about these basic processes in prototype supersonic combustors. Finite-rate chemistry effects are particularly important. Finite-rate chemistry in a supersonic combustor can affect the thrust (from slow radical recombination), shock positions (through changes in the ratio of specific heats) and the combustion efficiency (from flame extinction effects). Vibrational Raman scattering (VRS) has been used extensively in subsonic hydrogen-fueled flames to obtain time-and-space resolved

measurements of flow properties. The advantage of the VRS probe is that all the major species (H_2 , H_2O , O_2 , and N_2), temperature, density, and pressure can be determined simultaneously. Each of the molecular species produces a Raman spectrum at a unique wavelength and the signal related to the flow properties. Since the Raman probe measures all the reactants, products, and temperature, finite-rate chemistry effects can be determined. As discussed here, recently developed excimer lasers that operate at UV wavelengths can substantially enhance VRS probes for turbulent supersonic combustion measurement. The ultimate aim of this UV Raman work is to: (1) Develop a UV Raman probe with improved performance over conventional visible laser systems; (2) Apply the VRS probe to a well defined supersonic combustor such as a co-flowing, axisymmetric turbulent hydrogen jet diffusion flame; and (3) Quantify the effects of finite-rate chemistry and compressibility in a supersonic turbulent flame. Efforts to attain the first goal are described. Author

N90-26903* # Vanderbilt Univ., Nashville, TN. Dept. of Mechanical Engineering.

CONCENTRATION, TEMPERATURE, AND DENSITY IN A HYDROGEN-AIR FLAME BY EXCIMER-INDUCED RAMAN SCATTERING

JOSEPH A. WEHRMEYER, JOHN M. BOWLING, and ROBERT W. PITZ /n Sandia National Labs., Summary of Discussions at the Eleventh Meeting of the Sandia Cooperative Group on the Aerothermochemistry of Turbulent Combustion p 34-40 Oct. 1988

(Contract NAG1-770)

Avail: NTIS HC A03/MF A01 CSCL 21/2

Single-pulse, vibrational Raman scattering (VRS) is an attractive laser diagnostic for the study of supersonic hydrogen-air combustion. The VRS technique gives a complete thermodynamic description of the gas mixture at a point in the reacting flow. Single-pulse, vibrational Raman scattering can simultaneously provide independent measurements of density, temperature, and concentration of each major species (H_2 , H_2O , O_2 and N_2) in a hydrogen/air turbulent combustor. Also the pressure can be calculated using the ideal gas law. However, single-pulse VRS systems in current use for measurement of turbulent combustion have a number of shortcomings when applied to supersonic flows: (1) slow repetition rate (1 to 5 Hz), (2) poor spatial resolution ($0.5 \times 0.3 \times 0.3$ cu mm), and (3) marginal time resolution. Most of these shortcomings are due to the use of visible wavelength flash-lamp pumped dye lasers. The advent of UV excimer laser allows the possibility of dramatic improvements in the single-pulse, vibrational Raman scattering. The excimer based VRS probe will greatly improve repetition rate (100 to 500 Hz), spatial resolution ($0.1 \times 0.1 \times 0.1$ cu mm) and time resolution (30ns). These improvements result from the lower divergence of the UV excimer, higher repetition rate, and the increased Raman cross-sections (15 to 20 times higher) at ultra-violet (UV) wavelengths. With this increased capability, single-pulse vibrational Raman scattering promises to be an ideal non-intrusive probe for the study of hypersonic propulsion flows. Author

N90-26933* # Stanford Univ., CA. Dept. of Mechanical Engineering.

TURBULENT REACTING FLOWS AND SUPERSONIC COMBUSTION Final Report, 1 Oct. 1986 - 30 Sep. 1989

C. T. BOWMAN, RONALD K. HANSON, M. G. MUGAL, and W. C. REYNOLDS 15 Jan. 1990 38 p

(Contract F49620-86-K-0022; AF PROJ. 3484)

(AD-A221793; AFOSR-90-0504TR) Avail: NTIS HC A03/MF A01 CSCL 21/2

An experimental and computational investigation of supersonic combustion flows was carried out. The principal objective of the research was to gain a more fundamental understanding of mixing and chemical reaction in supersonic flows. The research effort comprised three inter-related elements: (1) an experimental study of mixing and combustion in a supersonic plane mixing layer; (2) development of laser-induced fluorescence techniques for time-resolved two-dimensional imaging of species concentration,

temperature and velocity; and (3) numerical simulations of compressible reacting flows. The specific objectives and the results of the research is summarized. GRA

N90-26972* # NSI Technology Services Corp., Dayton, OH.

THE ACUTE, DELAYED NEUROTOXICITY EVALUATION OF TWO JET ENGINE OIL FORMULATIONS Final Report, May - Oct. 1989

E. R. KINKEAD, S. R. BUNGER, R. E. WOLFE, and H. G. WALL Apr. 1990 25 p

(Contract F33615-85-C-0532; AF PROJ. 6302)

(AD-A222018; AAMRL-TR-90-018; NMRI-90-16) Avail: NTIS HC A03/MF A01 CSCL 06/11

This study was designed to determine the potential of two jet oils to produce acute, delayed neurotoxicity. The hydrocarbon-based ester oil formulation contained 3 percent tricresyl phosphate isomers, including triorthocresyl phosphate (TOCP) in one of the formulations. Hens were orally dosed over a five-day period and then observed for a total period of 30 days. All TOCP-positive control hens demonstrated signs of acute, delayed neurotoxicity. Hens from both jet engine oil groups remained asymptomatic throughout the observation period. No neurotoxic hazard would be expected for military or civilian personnel involved in the manufacture, transportation, or handling of these compounds. GRA

N90-26992* # EA Engineering Science and Technology, Inc., Lafayette, CA.

ENHANCED BIORECLAMATION OF JET FUELS: A FULL-SCALE TEST AT EGLIN AFB, FLORIDA Final Report, Nov. 1986 - Nov. 1988

R. E. HINCHEE, D. C. DOWNEY, J. K. SLAUGHTER, D. A. SELBY, M. S. WESTRAY, and G. M. LONG Sep. 1989 179 p

(Contract F08635-86-C-0341; AF PROJ. 2103)

(AD-A222348; AFESC/ESL-TR-88-78) Avail: NTIS HC A09/MF A01 CSCL 21/4

The results are presented of a full scale field test of enhanced biodegradation conducted at a JP-4 jet fuel spill site on Eglin AFB FL. A complete description of site characterization methods, the enhanced biodegradation process and hardware, and the impact of this technology on soil and ground water contaminants is provided. The treatment limitations of this technology that were observed through intense monitoring of soil and ground water-contaminant profiles are emphasized. Significant problems with hydrogen peroxide decomposition were documented in this test. This rapid decomposition resulted in poor oxygen distribution and biodegradation rates which were far less than laboratory microcosm studies had predicted. Several recommendations for improving field applications of enhanced biodegradation are provided, including a checklist for performing pilot tests of this technology. GRA

N90-26994* # Argonne National Lab., IL. Materials and Components Technology Div.

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE THERMAL DECOMPOSITION OF AVIATION FUELS Final Report, Sep. 1988 - Dec. 1989

JOHN L. KRAZINSKI and S. P. VANKA Dec. 1989 128 p

(Contract MIPR-FY1455-86-N0657; AF PROJ. 2480)

(AD-A221673; WRDC-TR-89-2139) Avail: NTIS HC A07/MF A01 CSCL 21/4

This report describes the development of a mathematical model for predicting the rate of thermal decomposition of aviation fuels. The model provides a global description of the chemical and physical processes of fuel autoxidation, precursor formation, and deposition at a solid surface. The model contains several unknown parameters that must be determined for a particular fuel. Calibration of the model involves the determination of these parameters from experimental data. This report describes the calibration procedure and presents sample calculations from the calibrated model for both laminar and turbulent flows. Prior to development of the model, the existing literature was surveyed to assess available information on those physical and chemical processes relevant to the thermal decomposition problem. The report describes the results of a brief

literature review covering the areas of fuel chemistry, transport processes, surface adhesion phenomena, and deposit-removal mechanisms. The report also discusses the existing data base for the thermal decomposition of aviation fuels. The data base consists primarily of results from heated-tube experiments, in which the rate of deposit formation is measured along the length of the tube. The deposition rates are typically correlated with the initial tube wall temperatures. GRA

N90-27787*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EVALUATION OF COMPOSITE COMPONENTS ON THE BELL 206L AND SIKORSKY S-76 HELICOPTERS

DONALD J. BAKER (Army Aerostructures Directorate, Hampton, VA.) Washington Aug. 1990 38 p Presented at the 8th DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Norfolk, VA, 28-30 Nov. 1989

(Contract DA PROJ. 1L1-62211-A-47-AB)

(NASA-TM-4195; L-16776; NAS 1.15:4195;

AVSCOM-TR-90-B-004) Avail: NTIS HC A03/MF A01 CSCI 11/4

Progress on two programs to evaluate structural composite parts in flight service on Bell 206L and Sikorsky S-76 commercial helicopters is described. Forty ship sets of composite parts that include the litter door, baggage door, forward fairing, and vertical fin were installed on Bell Model 206L helicopters that are operating in widely different climates. Part installation started in 1981 and selected parts are being removed and tested at prescribed intervals over a 10 yr evaluation. Four horizontal stabilizers and eleven tail rotor spars that are production parts on the S-76 helicopter are being tested after prescribed periods of service to determine the effects of the operating environment on their performance. Concurrent with the flight evaluation, materials used to fabricate the parts are being exposed in ground racks and tested at specified intervals to determine the effects of outdoor environments. Results achieved from 123,000 hrs of accumulated service on the Bell 206L parts and 53,000 hrs on the Sikorsky S-76 parts are reported. Seventy-eight Bell 206L parts were removed and tested statically. Results of 7 yrs of ground exposure of materials used to make the Bell 206L parts are presented. Author

N90-27788*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A PROTECTION AND DETECTION SURFACE (PADS) FOR DAMAGE TOLERANCE

MARK J. SHUART, CHUNCHU B. PRASAD, and SHERRILL B. BIGGERS (Lockheed Aeronautical Systems Co., Burbank, CA.) Washington Sep. 1990 21 p

(NASA-TP-3011; L-16775; NAS 1.60:3011) Avail: NTIS HC A03/MF A01 CSCI 11/4

A protection and detection surface (PADS) concept was studied for application to composite primary aircraft structures. A Kevlar-epoxy woven face sheet with a Rohacell foam core was found to be the most effective PADS configuration among the configurations evaluated. The weight of the PADS configuration was estimated to be approximately 17 pct of the structural weight. The PADS configuration was bonded to graphite-epoxy base laminates, and up to a 70 pct improvement in compression-after-impact failure strains was observed. Author

N90-27883# Research Inst. of National Defence, Stockholm (Sweden). Dept. of Weapon Systems, Effects and Protection.

REINFORCING FIBERS AND TECHNOLOGY DEVELOPMENT FOR RESIN COMPOSITES. CONSEQUENCES FOR AIRCRAFT STRUCTURES

FRITZ LARSSON Jan. 1990 50 p In SWEDISH; ENGLISH summary

(FOA-C-20777-2.5; ISSN-0347-3694; ETN-90-97097) Avail: NTIS HC A03/MF A01

A review is made concerning fibers used in advanced load carrying structures. Fiber covered are carbon, boron, silicon carbide, aramide, polyethylene, metal and metallized fibers, and thermoplastic fibers such as matrix resin. Modern fiber technologies

like hybrid reinforcement and three dimensional reinforcement are also covered. A weight reduction of up to 50 percent is possible, by using high tensile strength carbon fiber compounds, compared with the standard production. Three dimensional weave, three dimensional twisting, stitching (interlaced or uninterlaced) are more harm supporting than the unknown ones. Trends for using materials for the construction of military aircraft up to the year 2010 are presented. ESA

N90-27895# Centre d'Essais Aeronautique Toulouse (France). Lab. de Chimie et d'Etudes des Materiaux Cabine.

TOXICITY OF THERMOLYSIS PRODUCTS FROM THE MATERIALS OF AIRPLANE COCKPITS Final Report

[TOXICITE DES PRODUITS DE THERMOLYSE DES MATERIAUX DE CABINE D'AVION. PROCES-VERBAL DE L'ESSAI NO. M6 5924/02 ET FINAL]

ANNE MANSUET 1989 67 p In FRENCH

(Contract DRET-86-1031-01)

(CEAT-PV-M6/5924/02; ETN-90-97442) Avail: NTIS HC A04/MF A01

A technique for evaluating the toxicity of thermolysis products was developed. The aim of the work is the validation of the technique under aeronautic test conditions. Five materials are tested and three data analysis procedures are performed. Comparison with other results is effectuated. The investigation allows the classification of the materials as a function of their burning characteristics. ESA

N90-27900# Universite de Technologie de Compiègne (France). Div. Mecanique.

STUDY OF THE MICROSTRUCTURE OF A TITANIUM ALLOY (6246) FOR TURBOMACHINE COMPRESSORS (ETUDE MICROSTRUCTURALE D'UN ALLIAGE DE TITANE (6246) POUR COMPRESSEUR DE TURBOMACHINE)

A. S. BERANGER-BOURSIER and M. CLAVEL Oct. 1989 79 p In FRENCH

(Contract DRET-88-1156)

(ETN-90-97450) Avail: NTIS HC A05/MF A01

Samples from titanium 6246 cast bars are analyzed. Beta and alpha/beta compositions are investigated. Tensile tests are performed. The alloy shows high and isotropic mechanical resistance, for temperatures up to 500 C. The beta-alloy shows some dispersion concerning toughness properties. The reasons for such dispersion in the results is investigated. The analysis of the microstructure for different fracture and deformation modes, as well as a quantitative and statistical study of the sample's metallography are presented. ESA

N90-27905# Centre d'Essais Aeronautique Toulouse (France). Lab. des Materiaux Metalliques.

CHARACTERIZATION OF THE CP 214 T851. DISSECTION OF A CAST FLAT BAR FOR A STANDARD SPAR Test Report [CARACTERISATION DU CP214 T851. DISSECTION D'UN MEPLAT FORGE CAPABLE D'UN LONGERON STANDARD. PROCES VERBAL DE L'ESSAI NO. M4 462200]

G. MARQUIER 17 Apr. 1990 90 p In FRENCH

(Contract STPA-82-96042)

(CEAT-PV-M4/462200; ETN-90-97441) Avail: NTIS HC A05/MF A01

The purpose of the research program is the characterization of a CP214 cast flat bar. A dissection analysis is carried out for the construction of a numerical data base of standards to be used in comparative analysis. The bar is used to manufacture an aircraft structural component named standard spar. Several aluminum alloys are investigated. Bend tests were performed on a manufactured spar. The material manufacturing parameters, the assembling technologies and the loading characteristics are examined. ESA

N90-27906# Centre d'Essais Aeronautique Toulouse (France).
Lab. des Materiaux Metalliques.

CHARACTERIZATION OF THE 7175 T7352. DISSECTION OF A DIE CASTING STANDARD SPAR Test Report
[CARACTERISATION DU 7175 T7352. DISSECTION D'UN LONGERON STANDARD BRUT DE MATRICAGE. PROCES VERBAL DE L'ESSAI NO. M5 528900]

G. MARQUIER 2 Jun. 1989 95 p In FRENCH
(Contract STPA-83-96024)
(CEAT-PV-M5/528900; ETN-90-97443) Avail: NTIS HC A05/MF A01

The purpose of the research program is the characterization of a 7175 T7352 die casting bar. A dissection analysis is carried out for the construction of a numerical data base of standards, to be used in comparative analysis. The rod is used to manufacture an aircraft structural component named standard spar. Several aluminum alloys are investigated. Bend tests were performed on a manufactured spar. The material manufacturing parameters, the assembling technologies and the loading characteristics are examined. ESA

N90-27907# Centre d'Essais Aeronautique Toulouse (France).
Lab. de Materiaux Metalliques.

CHARACTERIZATION OF THE 7175 T7352 101. DISSECTION OF A DIE CASTING STANDARD SPAR Test Report
[CARACTERISATION DU 7175 T7352 101. DISSECTION D'UN LONGERON STANDARD BRUT DE MATRICAGE. PROCES VERBAL DE L'ESSAI NO. M5 5288]

G. MARQUIER 1989 91 p In FRENCH
(Contract STPA-83-96024)
(CEAT-PV-M5/5288; ETN-90-97444) Avail: NTIS HC A05/MF A01

The purpose of the research program is the characterization of a 7175 T7352 die casting bar. A dissection analysis is carried out for the construction of a numerical data base of standards, to be used in comparative analysis. The rod is used to manufacture an aircraft structural component named standard spar. Several aluminum alloys are investigated. Bend tests were performed on a manufactured spar. The material manufacturing parameters, the assembling technologies and the loading characteristics are examined. ESA

N90-27908# Centre d'Essais Aeronautique Toulouse (France).
Lab. des Materiaux Metalliques.

CHARACTERIZATION OF THE 7010 T73651. DISSECTION OF A SHEET BILLET FOR A STANDARD SPAR Test Report
[CARACTERISATION DU 7010 T73651. DISSECTION D'UN LARGET DE TOLE CAPABLE D'UN LONGERON STANDARD. PROCES VERBAL DE L'ESSAI NO. 5 M5 521700]

G. MARQUIER 10 May 1989 90 p In FRENCH
(Contract STPA-83-96013)
(CEAT-PV-M5/521700; ETN-90-97445) Avail: NTIS HC A05/MF A01

The purpose of the research program is the characterization of a 7175 T7352 die casting bar. A dissection analysis is carried out for the construction of a numerical data base of standards, to be used in comparative analysis. The rod is used to manufacture an aircraft structural component named standard spar. Several aluminum alloys are investigated. Bend tests were performed on a manufactured spar. The material manufacturing parameters, the assembling technologies and the loading characteristics are examined. ESA

N90-27935*# M L Energia, Inc., Princeton, NJ.
PHOTO-SENSITIZED IGNITION OF HYDROGEN/OXYGEN MIXTURES FOR HYPERSONIC FLIGHT VEHICLES
MOSHE LAVID, ARTHUR T. POULOS, and JOHN G. STEVENS
/In Johns Hopkins Univ., The 26th JANNAF Combustion Meeting, Volume 1 p 441-462 Oct. 1989
(Contract NAS2-12782)

Avail: NTIS HC A23/MF A03 CSCL 21/9

An approach toward improving supersonic ignition and combustion efficiency was investigated under a feasibility program

with NASA-Ames. The idea is to selectively irradiate targeted species in the combustion zone. The ensuing photodissociation reactions produce highly reactive radicals which modify the gas phase kinetics. The overall objective of this research was to demonstrate photosensitized ignition of H₂/O₂ mixtures, and to gain a preliminary understanding of the ignition mechanism, especially as it pertains to the concept of supersonic combustion. To this end, a series of experiments were performed with a model sensitizer, NO₂. At subatmospheric pressures and moderate temperatures (above 100 F), mixtures of H₂/O₂/NO₂ are ignitable by a pulsed excimer laser at 308 nm, 115 to 200 mJ. Ignitability was found to be a function of NO₂ pressure, temperature, laser energy per pulse, and laser lens focal length (fluence at focal volume). Mixtures could not be ignited in the absence of the sensitizer. While increasing temperature improved sensitized ignition in the lower temperature range, a retarding effect was observed at the highest temperatures. To more thoroughly understand these thermal effects, the UV-Vis and IR spectra of NO₂ and H₂/O₂/NO₂ mixtures were studied over the temperature range 70 to 900 F. Initially, increasing temperature shifts the N₂O₄ in a reversible reaction to 2 NO₂ equilibrium toward NO₂, favoring photochemical ignition. However, at still higher temperature, NO₂ converts to non-absorbing NO + 1/2 O₂, thus preventing photosensitized ignition. Author

N90-28070# German Air Force, Cologne (Germany, F.R.). Air Materiel Office.

NDI-CONCEPT FOR COMPOSITES IN FUTURE MILITARY AIRCRAFT

MATTHIAS STOERMER /In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 8 p May 1990

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Helicopters and fixed wing aircraft entering service with the German Air Force, and the use of composites in these aircraft are reviewed. Past experiences with composites and with existing nondestructive inspection (NDI) techniques are used to identify some of the anticipated NDI requirements for the next generation aircraft. It is expected that if the level of effort devoted to inspection is to be kept within reasonable bounds, increased effort will be needed to develop improved NDI techniques and to provide training to Air Force craftsman to make them aware of the characteristics of composite materials and the types of flaws and defects that they are likely to contain. The use of artificial intelligence in NDI is also expected to increase, and a review of some of the German work in the area is provided. Author

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A90-45960
RANGE DETERMINATION IN A MULTIPATH PRONE ENVIRONMENT

G. BORTZ, J. J. VAN SCHALKWYK, and W. LOUW (Pretoria, University, Republic of South Africa) Electronics Letters (ISSN 0013-5194), vol. 26, Aug. 2, 1990, p. 1253, 1254. refs

Copyright

The distance of the closest point of approach, along an aircraft flight path, to a beacon is required. Aircraft/beacon range information is achieved by the use of a dual Doppler technique.

The Dopplers are corrupted by multipath interference. Two digital tracking filters succeed in significantly reducing errors in range caused by the multipath signals. Author

A90-45971

TORSIONAL BUCKLING AND POST-BUCKLING OF COMPOSITE GEODETIC CYLINDERS WITH SPECIAL REFERENCE TO JOINT FLEXIBILITY

J. S. SANDHU, K. A. STEVENS, and G. A. O. DAVIES (Imperial College of Science, Technology, and Medicine, London, England) Composite Structures (ISSN 0263-8223), vol. 15, no. 4, 1990, p. 301-322. Research supported by SERC and Ministry of Defence. refs

Copyright

Curved (geodetic) composite frameworks are being considered for battle-damage tolerant helicopters. Upon detailed experimental testing of isolated geodetic joints it was realized that joint flexibility is an important factor in the overall behavior of the shell. When this joint flexibility is incorporated in the finite element models of the geodetic joint test specimens the differences between experiment and theory are dramatically reduced. This is also true for the complete shell where the buckling torque, calculated from linear finite element analysis, now exceeds the experimental value by about 12 percent, while for the nonlinear analysis the discrepancy is reduced to below 7 percent. Compression tests of the cylindrical geodetic shell confirm that the finite element model incorporating joint flexibility produces much better results for the compression stiffness. Author

A90-46036

PREDICTION AND MEASUREMENT OF ROTOR BLADE/STATOR VANE DYNAMIC CHARACTERISTICS OF A MODERN AERO-ENGINE AXIAL COMPRESSOR

R. J. WILLIAMS, K. L. JOHAL, H. A. BARTON, and S. T. ELSTON (Rolls-Royce, PLC, Aero-engine Div., Derby, England) IN: Modern practice in stress and vibration analysis; Proceedings of the Conference, Liverpool, England, Apr. 3-5, 1989. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 163-169.

Copyright

Commercial pressures require ever more fuel-efficient and lightweight propulsion systems. Inevitably this results in an increased stage loading that can exacerbate vibration problems of stall flutter, acoustic resonance, and conventional mechanical resonances from the immediate upstream and downstream blade/vane rows. This paper traces the design of a rotor and stator from design to engine validation. The components are analyzed at design stage using finite-element models and modified to give acceptable dynamic characteristics. The predicted and measured results are compared, and the method of assessment described. Author

A90-46037

THEORETICAL AND EXPERIMENTAL DETERMINATION OF NATURAL FREQUENCIES OF LACED BLADING

G. M. CHAPMAN and X. WANG (Loughborough University of Technology, England) IN: Modern practice in stress and vibration analysis; Proceedings of the Conference, Liverpool, England, Apr. 3-5, 1989. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 171-179. Research supported by Napier Turbochargers, Ltd.

Copyright

A lacing wire is often introduced into the gas-turbine blading of large turbochargers to minimize vibration of the blades. This paper describes theoretical and experimental investigations aimed at developing an understanding of the relationship between the blading and the lacing wire. It discusses the experimental procedures developed and reinforces the results obtained by comparison with a finite-element analysis of the blade assembly. The investigation progresses from a full study of single unlaced blades to single laced blades and finally reports on the vibration behavior of multiple-laced-blade assemblies. Author

A90-46038

COMPARISON AMONG MODAL ANALYSES OF AXIAL COMPRESSOR BLADE USING EXPERIMENTAL DATA OF DIFFERENT MEASURING SYSTEMS

G. D'EMILIA (L'Aquila, Universita, Italy), C. SANTOLINI, and E. P. TOMASINI (Ancona, Universita, Italy) IN: Modern practice in stress and vibration analysis; Proceedings of the Conference, Liverpool, England, Apr. 3-5, 1989. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 191-199. refs

Copyright

Results are reported from comparative modal-analysis measurements on an axial-compressor blade. Data obtained at 0-5000 Hz using (1) an eddy-current-probe proximity transducer, (2) a laser Doppler vibrometer, and (3) a very lightweight accelerometer were processed using the same software package, correcting for known instrument biases. The results are presented in tables and graphs and characterized in detail. Good general agreement among the three measurement systems is found, but system (3) did not give accurate results near the blade tip at the highest frequencies. T.K.

A90-46039

OLD LAMPS FOR NEW - A PHOTOELASTIC DESIGN TOOL FOR WEIGHT AND COST SAVING ON AIRCRAFT STRUCTURES

E. W. O'BRIEN (British Aerospace Commercial Aircraft, Ltd., Airbus Div., Bristol, England) IN: Modern practice in stress and vibration analysis; Proceedings of the Conference, Liverpool, England, Apr. 3-5, 1989. Oxford, England and Elmsford, NY, Pergamon Press, 1989, p. 235-243.

Copyright

The theoretical basis and practical implementation of photoelastic stress analysis (PSA) are reviewed, and the application of PSA in the design and weight minimization of aircraft structural components is described and illustrated with drawings and diagrams. Birefringent crystals, plane and circular polariscopes, photoelastic models, fringe patterns, and the photoelastic equations are briefly discussed. Particular attention is then given to PSA for verification of FEM modeling; PSA checks on the accuracy of strain-gage placement; PSA identification of low-stress areas where weight savings are possible; and the use of PSA in the design of the Concorde rudder, the A340 spoiler actuator mounting, and the A340 landing-gear pintle fitting. T.K.

A90-46184

HOMOGENIZATION OF COMPOSITE BEAMS IN DYNAMICAL FLEXURE

M. CARRIER, J. M. CIEAUX, and D. GAY (Toulouse III, Universite, France) IN: Structural vibration and acoustics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 183-187.

Copyright

Structures such as helicopter rotor blades and composite shafts can be ranked as composite beams. This paper describes a procedure for homogenizing composite beams in dynamical flexure, where the beams are made of phases of different materials. The procedure takes into account shear deformation and rotary inertia of the section. The coupling between flexure, torsion, and stretching is defined by means of stiffness and mass matrices. The model provides good agreement between the numerical and experimental results. I.S.

A90-46186

VIBRATION ANALYSIS OF LACED BLADES

G. M. CHAPMAN and X. WANG (Loughborough University of Technology, England) IN: Structural vibration and acoustics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 207-213. Research supported by Napier Turbochargers, Ltd.

Copyright

Lacing wires are commonly used to reduce stimulated vibration

in the gas turbine stage of large turbochargers. This paper reports on an investigation into the effect of lacing wire location on the natural frequencies of a single blade, it develops an understanding of the effect of coupling blades together through the use of a common lacing wire and comments on the coupled combination frequencies generated. Author

A90-46188

FULL SPAN ANALYSIS FOR FLUTTER PREDICTION OF SLENDER BLADE ASSEMBLIES

B. VINCENT and R. HENRY (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) IN: Structural vibration and acoustics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 223-230. Research supported by SNECMA. refs Copyright

The general procedure used to predict flutter instability is detailed. The proposed method is well suited for bladed assemblies composed of slender blades vibrating with an axisymmetric behavior. The blades are modeled by beam finite elements. The unsteady aerodynamic coefficients are determined using the strip theory assumption. Computing the unsteady aerodynamic forces per unit span at several spanwise locations and transforming them into finite element equivalent nodal forces, produce a consistent coupled system. To illustrate the theory, a simple bladed assembly vibrating in torsion in an incompressible unsteady flow is detailed along with the data required and computed results. Finally, a tentative method to shorten the full span procedure is examined and discussed. Author

A90-46190

VIBRATION OF TURBINE BLADES DAMPED BY DRY FRICTION FORCES

W. OSTACHOWICZ (Polska Akademia Nauk, Instytut Maszyn Przeplywowych, Gdansk, Poland) IN: Structural vibration and acoustics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 255-258. refs Copyright

The object of the paper is to present a method of analysis of forced vibrations of a turbine blade taking into account dry friction forces at the dampers. The method relies upon assuming the solution in the form of Fourier series and applying the harmonic balance method. Described in the paper is a method that can be used for vibration analysis of gas and steam turbine blades and blades of axial compressors. The analysis is provided with an algorithm and an example of calculations. Author

A90-46215

THE ROLE OF BEARING SUPPORT STIFFNESS ANISOTROPY IN SUPPRESSION OF ROTORDYNAMIC INSTABILITY

F. EHRICH (GE Aircraft Engines, Lynn, MA) IN: Rotating machinery dynamics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 269-274. refs Copyright

A generalized class of rotordynamic instabilities may be characterized by a force generated by a cross coupled stiffness; i.e., a force which is proportional to the rotor deflection but which acts in a direction normal to the deflection. The effect of an anisotropic support system on the stability boundary of such a system is analyzed. The stability boundary in terms of the maximum value of allowable cross-coupled stiffness is computed for a representative range of values of support stiffness anisotropy and of system-damping ratios, by means of a closed-form exact solution to the dynamic equations at the stability boundary. This solution also defines the orbital motion at the stability boundary. The orbit is always an ellipse tilted 135 deg to the major principal elastic axis. It is shown that anisotropy is very effective in suppression of

instability for very lightly damped systems, but is very much less so for systems with higher damping. Author

A90-46222* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ACTIVE VIBRATION CONTROL FOR FLEXIBLE ROTOR BY OPTIMAL DIRECT-OUTPUT FEEDBACK CONTROL

K. NONAMI, E. DIRUSSO, and D. P. FLEMING (NASA, Lewis Research Center, Cleveland, OH) IN: Rotating machinery dynamics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 327-333. Previously announced in STAR as N89-22605. refs Copyright

Experimental research tests were performed to actively control the rotor vibrations of a flexible rotor mounted on flexible bearing supports. The active control method used in the tests is called optimal direct-output feedback control. This method uses four electrodynamic actuators to apply control forces directly to the bearing housings in order to achieve effective vibration control of the rotor. The force actuators are controlled by an analog controller that accepts rotor displacement as input. The controller is programmed with experimentally determined feedback coefficients; the output is a control signal to the force actuators. The tests showed that this active control method reduced the rotor resonance peaks due to unbalance from approximately 250 microns down to approximately 25 microns (essentially runout level). The tests were conducted over a speed range from 0 to 10,000 rpm; the rotor system had nine critical speeds within this speed range. The method was effective in significantly reducing the rotor vibration for all of the vibration modes and critical speeds. Author

A90-46226* Texas A&M Univ., College Station.

TEST AND THEORY FOR PIEZOELECTRIC ACTUATOR-ACTIVE VIBRATION CONTROL OF ROTATING MACHINERY

A. B. PALAZZOLO, R. R. LIN, R. M. ALEXANDER (Texas A & M University, College Station), A. F. KASCAK (NASA, Lewis Research Center; U.S. Army, Cleveland, OH), and J. MONTAGUE (Sverdrup Technology, Inc., Middleburg Heights, OH) IN: Rotating machinery dynamics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 367-374. Research supported by Texas A & M Turbomachinery Research Consortium. refs Copyright

The application of piezoelectric actuators for active vibration control (AVC) of rotating machinery is examined. Theory is derived and the resulting predictions are shown to agree closely with results of tests performed on an air turbine driven-overhung rotor. The test results show significant reduction in unbalance, transient and sub-synchronous responses. Results from a 30-hour endurance test support the AVC system reliability. Various aspects of the electro-mechanical stability of the control system are also discussed and illustrated. Finally, application of the AVC system to an actual jet engine is discussed. Author

A90-46228* Southwest Research Inst., San Antonio, TX.

SPRAY AUTOMATED BALANCING OF ROTORS - HOW PROCESS PARAMETERS INFLUENCE PERFORMANCE

A. J. SMALLEY, R. M. BALDWIN (Southwest Research Institute, San Antonio, TX), D. P. FLEMING (NASA, Lewis Research Center, Cleveland, OH), and J. S. YUHAS (U.S. Army, Propulsion Directorate, Cleveland, OH) IN: Rotating machinery dynamics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 381-387. refs Copyright

This paper addresses the application of spray-automated balancing of rotors, and the influence that various operating parameters will have on balancing performance. Spray-automated

balancing uses the fuel-air repetitive explosion process to imbed short, discrete bursts of high velocity, high temperature powder into a rotating part at an angle selected to reduce unbalance of the part. The shortness of the burst, the delay in firing of the gun, the speed of the disk and the variability in speed all influence the accuracy and effectiveness of the automated balancing process. The paper evaluates this influence by developing an analytical framework and supplementing the analysis with empirical data obtained while firing the gun at a rotating disk. Encouraging results are obtained, and it is shown that the process should perform satisfactorily over a wide range of operating parameters. Further experimental results demonstrate the ability of the method to reduce vibration levels induced by mass unbalance in a rotating disk. Author

A90-46236

ADVANCED ANALYSIS OF MULTI-RING LIQUID SEALS

S. W. REEDY (Cummins Engine Co., Columbus, IN) and R. G. KIRK (Virginia Polytechnic Institute and State University, Blacksburg) IN: Machinery dynamics - Applications and vibration control problems; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 129-134. refs

Copyright

The equilibrium position of multi-ring seal assemblies is of major importance to the designer of high pressure centrifugal compressors. Typical computer codes now use a curve-fit of the Short Bearing Sommerfeld Number for eccentricity evaluation with the assumption that all rings in the assembly will always operate at the same eccentricity. The results from the recently developed seal analysis program, SEALS, have shown that the equal eccentricity assumption for multi-ring seals is questionable. This paper will review the analysis procedure used in SEALS, and present the results of an eccentricity evaluation comparison with a seal analysis program currently being used in industry. Author

A90-46237

UNBALANCE RESPONSE OF A JEFFCOTT ROTOR INCORPORATING LONG SQUEEZE FILM DAMPERS

A. EL-SHAFAEI (South Florida, University, Tampa, FL) IN: Machinery dynamics - Applications and vibration control problems; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 149-158. refs

Copyright

The steady state unbalance response of a Jeffcott rotor incorporating long squeeze film dampers executing circular centered whirl is obtained. Fluid inertia forces are included in the model of the squeeze film dampers, using an energy approximation. The fluid velocity profiles are assumed not to change much due to fluid inertia, and the kinetic coenergy of the fluid is calculated. The fluid inertia forces are then obtained by Lagrange's equations in conjunction with Reynolds transport theorem. The unbalance response of the rotor is obtained by assuming circular centered whirl, and it is shown that fluid inertia results in the excitation of a second mode for the Jeffcott rotor and decreases the useful range of vibration isolation of the dampers. It is also shown that the second mode can exhibit the jump resonance phenomenon. Author

A90-46301

BULGING CRACKS IN PRESSURIZED FUSELAGES - A PROCEDURE FOR COMPUTATION

E. RIKS (Nationaal Lucht- en Ruimtevaartlaboratorium, Noordoostpolder, Netherlands), F. A. BROGAN, and C. C. RANKIN (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) IN: Analytical and computational models of shells; Proceedings of the Symposium, ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 483-507. refs

Copyright

Recent events with aging airliners suggest that it is time to develop further the tools of analysis of the behavior of cracks in pressurized fuselages. This paper is an attempt to contribute to this important issue. It describes a computational procedure for the energy release rates of through-cracks in thin walled cylindrical pressure hulls. Contrary to most of the problems concerning cracks in flat plates, the crack problem in a pressurized shell is geometrically nonlinear. Continuation procedures are required in this case, and such a procedure was recently implemented and tested in the STAGS code. The new STAGS capability offers the possibility to compute the energy release rates of a series of cracks along a predetermined crack path thereby allowing for considerable detail in the modeling of the structure that surrounds the crack. The feasibility of the approach is demonstrated by means of some examples. Author

A90-46478

SENSITIVITY ANALYSIS IN THE DESIGN OF COMPOSITE STRUCTURES [ANALIZ CHUVSTVITEL'NOSTI PRI PROEKTIROVANII KONSTRUKTSII IZ KOMPOZITOV]

V. A. ZARUBIN Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 3-7. In Russian. refs

Copyright

A procedure is described for calculating partial derivatives of limit functions (generalized displacements, natural frequencies, and aeroelastic characteristics) for two types of design variables (unidirectional layer thickness and fiber orientation angles in the layers) in the problem of composite structure design using finite element models. Results of a wing structure analysis carried out on a computer-aided design system using a finite element code are reported. The natural vibration modes and divergences are presented. V.L.

A90-46482

IDENTIFICATION OF A STRESS-STRAIN COMPUTATION MODEL AND PLANNING OF TENSOMETRY POINTS IN STRENGTH AND STABILITY STUDIES [IDENTIFIKATSIIA RASCHETNOI MODELI NDS I PLANIROVANIE TOCHEK TENZOMETRII PRI ISSLEDOVANIIAKH VOPROSOV PROCHNOSTI I USTOICHIVOSTI]

V. T. FADEEV and L. P. ZHELEZNOV Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 17-19. In Russian. refs

Copyright

A method is proposed for refining stress-strain computation models by representing the computed stress-strain state and tensometry data for a real structure at a certain set of points. The algorithm proposed here employs a finite-element method, which is commonly used in the analysis of aircraft structures. The problem of selecting the optimal version of strain gauge placement is examined. A program for the identification of the deformation model and of the structure is developed. V.L.

A90-46492

CALCULATION OF AN AXIAL-FLOW BIROTARY TURBINE [K RASCHETU OSEVOI BIROTATIVNOI TURBINY]

L. IA. LAZAREV and V. V. CHIZHOV Aviatsonnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 53-56. In Russian.

Copyright

A method is proposed for optimizing the parameters of an axial-flow birotary turbine. In particular, a system of equations is obtained which allows a comprehensive analysis of the parameters of the individual stages and of the turbine as a whole on the principal characteristics of the turbine: maximum efficiency and optimal xT value. Results of the calculations are presented. V.L.

A90-46541

A STUDY OF THE STABILITY AND THERMAL STABILITY OF COMPLEX REINFORCED STRUCTURES [ISSLEDOVANIE USTOICHIVOSTI I TERMOUSTOICHIVOSTI SLOZHNYKH PODKREPLENNYKH KONSTRUKTSII]

G. N. ZAMULA, K. M. IERUSALIMSKII, and G. S. KARPOVA TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 4, 1989,

p. 84-97. In Russian. refs

Copyright

A highly accurate numerical method developed in previous studies is used to develop a general-purpose algorithm and computer software for calculating the stability of complex reinforced structures consisting of a set of rods, plates, and shells. Results of mechanical and thermal stability studies are presented for the most common reinforced wing panels and a fuselage compartment under mixed loading. The allowance for loading nonuniformity and element coupling is shown to be important in stability calculations. V.L.

A90-46561

USING THE SMOKING-WIRE VISUALIZATION METHOD IN THE STUDY OF WING MODELS AT LARGE ANGLES OF ATTACK IN SUBSONIC WIND TUNNELS [ISPOL'ZOVANIE VIZUALIZATSIY METODOM DYMIAISHCHEI PROVOLOCHKI PRI ISSLEDOVANIYAKH MODELEY KRYL'EV NA BOL'SHIKH UGLAKH ATAHI V DOZVUKOVYKH AERODINAMICHESKIKH TRUBAKH]

V. I. BOGOMAZOV, S. I. INSHAKOV, and V. P. IANKOV TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 113-117. In Russian. refs

Copyright

Results of a smoking-wire visualization study are presented for wing models equipped with plane jet injection systems at supercritical angles of attack. The visualization data are compared with the results of weighing studies for the same wings. It is noted that the smoking wire method makes it possible to visualize both separated and nonseparated flows past models of different shapes with injection in subsonic wind tunnels at incoming flow velocities up to 15 m/s. V.L.

A90-46620

OPTOELECTRONIC GUIDANCE SENSORS (5TH REVISED AND ENLARGED EDITION) [OPTIKO-ELEKTRONNYE PRIBORY NAVEDENIYA /5TH REVISED AND ENLARGED EDITION/]

LEONID P. LAZAREV Moscow, Izdatel'stvo Mashinostroenie, 1989, 510 p. In Russian. refs

Copyright

This work reviews theoretical principles and design methods for optoelectronic flight-vehicle guidance sensors and the main sensor components, including optical and optoelectronic systems, image analyzers, and tracking coordinators. Particular attention is given to guidance systems based on lasers, and multicolor, pyroelectric, and CCD detectors. Structural, kinematic, optical, and electrical designs are described, and examples of device constructions and of their main elements are presented. B.J.

A90-46720#

A LEAP FORWARD IN AIRCRAFT CONSTRUCTION TECHNOLOGY - HIGH-SPEED CUTTING SETS NEW PRODUCTION STANDARDS

New-Tech News (ISSN 0935-2694), no. 2, 1990, p. 21-23.

Copyright

A new high-speed cutting (HSC) system which incorporates spindle positioning, operational temperature regulation, and status identification has reduced working time for an Airbus integral component measuring 2,300 x 220 x 110 mm (cut from an aluminum plate with a 94 percent machining degree) from 669 min to 396 min. A history of advances in high-speed cutting is provided and the new computerized, integrated, and automated manufacturing (CIAM) process, which succeeded in increasing actual cutting times in work cycles up to 80 percent, is described. The importance of cutter-spindle technology is stressed and three cutting machines developed by MBB in Augsburg are described. L.K.S.

A90-46899#

COMPUTATION OF COMPLEX FLOWS IN GAS TURBINE COMBUSTORS WITH A MULTI-LEVEL ADDITIVE CORRECTION TECHNIQUE

OSAMA M. F. ELBAHAR (Cairo University, Giza, Egypt) IN:

International Congress of Fluid Mechanics, 3rd, Cairo, Egypt, Jan. 2-4, 1990, Proceedings. Volume 3. Mansoura, Egypt, Mansoura University, 1990, p. 1171-1183. refs

The present contribution deals with the application of an additive correction technique for accelerating and stabilizing the numerical solution of the conservation equations of mass, momentum and energy as well as the governing equations for the turbulence kinetic energy and its dissipation rate. The performance of the new model is compared with both experimental results and the predictions of a line-iteration-based model. It is shown that the present model displays a much better performance during the prediction of complex flows typical of gas turbine combustors, especially if fine computational grids are applied. The numerical stability of the new model is proved to be superior to line-iteration-based models.

Author

A90-47021

LASER WELDING OF AN ADVANCED RAPIDLY-SOLIDIFIED TITANIUM ALLOY

W. A. BAESLACK, III, S. CHIANG, and C. A. ALBRIGHT (Ohio State University, Columbus) Journal of Materials Science Letters (ISSN 0261-8028), vol. 9, June 1990, p. 698-702. refs

Copyright

The laser weldability of a complex RS titanium alloy containing yttrium is investigated by evaluating comparatively the microstructures, mechanical properties, and fracture characteristics of the base metal and the rapidly solidified weld fusion zone. To prevent atmospheric contamination the specimen was enclosed in a helium-purged plastic bag during the welding process. After welding, the coupons were sectioned transverse to the laser beam direction of traverse, epoxy mounted, polished down to 0.05 micron SiO₂ and etched with Kroll's reagent for examination utilizing light and SEM and energy-dispersive X-ray analysis. Results indicate that laser welding is effective in producing a fine fusion zone dispersoid structure in the RS Ti composite. R.E.P.

A90-47118

THE SURFACE PRETREATMENT OF ALUMINIUM-LITHIUM ALLOYS FOR STRUCTURAL BONDING

J. A. BISHOPP (Ciba-Geigy Plastics, Cambridge, England), D. JOBLING, and G. E. THOMPSON (University of Manchester Institute of Science and Technology, England) (IME, University of Bristol, Institute of Physics, et al., International Conference on Structural Adhesives in Engineering II, Bristol, England, Sept. 20-22, 1990) International Journal of Adhesion and Adhesives (ISSN 0143-7496), vol. 10, July 1990, p. 153-160. refs

Copyright

The effects of several standard chemical surface treatments (combinations of potassium dichromate/sulfuric acid pickle, chromic acid anodizing, and phosphoric acid anodizing) on the strength of Al-Li alloy bonded joints were compared using the results of TEM examinations of ultrathin sections obtained by cutting through structural joints bonded by an epoxy adhesive. Simultaneously, the initial adhesive/adherent interfacial analysis of these joints was carried out. It was found that the films formed on the aluminum-lithium surface as a result of different pretreatments were similar. The films appeared to be wetted and, in some cases, were penetrated by the adhesive. Substrates pickled in potassium dichromate/sulfuric acid performed better than those anodized in phosphoric acid. I.S.

A90-47203*# Florida Univ., Gainesville.

EFFECT OF VANE TWIST ON THE PERFORMANCE OF DOME SWIRLERS FOR GAS TURBINE AIRBLAST ATOMIZERS

GERALD J. MICKLOW, ANJU S. DOGRA (Florida, University, Gainesville), and H. LEE NGUYEN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 14 p. Previously announced in STAR as N90-25289. refs

(AIAA PAPER 90-1955) Copyright

For advanced gas turbine engines, two combustor systems, the lean premixed/prevaporized (LPP) and the rich burn/quick quench/lean burn (RQL) offer great potential for reducing NO(x)

emissions. An important consideration for either concept is the development of an advanced fuel injection system that will provide a stable, efficient, and very uniform combustion system over a wide operating range. High-shear airblast fuel injectors for gas turbine combustors have exhibited superior atomization and mixing compared with pressure-atomizing fuel injectors. This improved mixing has lowered NO(x) emissions and the pattern factor, and has enabled combustors to alternate fuels while maintaining a stable, efficient combustion system. The performance of high-shear airblast fuel injectors is highly dependent on the design of the dome swirl vanes. The type of swirl vanes most widely used in gas turbine combustors are usually flat for ease of manufacture, but vanes with curvature will, in general, give superior aerodynamic performance. The design and performance of high-turning, low-loss curved dome swirl vanes with twist along the span are investigated. The twist induces a secondary vortex flow pattern which will improve the atomization of the fuel, thereby producing a more uniform fuel-air distribution. This uniform distribution will increase combustion efficiency while lowering NO(x) emissions. A systematic swirl vane design system is presented based on one-, two-, and three-dimensional flowfield calculations, with variations in vane-turning angle, rate of turning, vane solidity, and vane twist as design parameters. Author

A90-47228* Texas A&M Univ., College Station.

VIBRATION DAMPERS FOR CRYOGENIC TURBOMACHINERY
ALAN B. PALAZZOLO, EMMANUEL OLAN, AZMAN SYED IBRAHIM (Texas A & M University, College Station), and ALBERT F. KASCAK (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990. 10 p. refs (AIAA PAPER 90-2740) Copyright

This paper describes the development of effective and reliable minimum-weight and minimum-envelope vibration dampers for cryogenic turbines. To meet this objective, a high speed test rig was designed and fabricated, which is currently used to test a curved beam type damper. The operation, capacity, structural characteristics, measurement system, and safety features of the cryogenic damper test rig are discussed. I.S.

A90-48045

ITERATIVE PRELIMINARY DESIGN TOOLS FOR COMPOSITE STRUCTURES

STEPHEN R. HALL (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) (USAF and Paisley College of Technology, International Workshop on Optimum Design of Composite Structures, Glasgow, Scotland, July 27, 1989) Composite Structures (ISSN 0263-8223), vol. 16, no. 1-3, 1990, p. 103-123. Research supported by the National Research Council of Canada. refs Copyright

Advanced composite materials offer tremendous potential for the optimization of aerospace structures from weight, cost, strength and stiffness perspectives. However, this potential cannot be realized without the aid of advanced composite design tools that have been specifically developed to exploit the unique properties of these materials. This paper presents the philosophy behind a system of semi-empirical composite design programs that have primarily been developed for the preliminary design environment. The structure of the system is described and problems encountered during the development of the system are discussed. Practical examples are used to illustrate the system capabilities. Author

A90-48047

DEVELOPMENTS IN THE ACOUSTIC FATIGUE DESIGN PROCESS FOR COMPOSITE AIRCRAFT STRUCTURES

R. G. WHITE (Southampton, University, England) (USAF and Paisley College of Technology, International Workshop on Optimum Design of Composite Structures, Glasgow, Scotland, July 27, 1989) Composite Structures (ISSN 0263-8223), vol. 16, no. 1-3, 1990, p. 171-192. Research sponsored by the Ministry of Defence Procurement Executive. refs Copyright

A current approach to the acoustic fatigue analysis of composite structures is reviewed which is based upon the single mode method used previously for metallic aircraft structures. Some recent developments in acoustic fatigue studies are outlined and progressive wave tube testing at elevated temperatures is described. A recently developed method for fatigue testing composite material specimens in flexure is presented together with fatigue data for a composite material in several environmental conditions. The occurrence of residual thermal stresses in composite materials has been studied and future work required concerning three-dimensional stress prediction methods and design procedures is discussed. Author

A90-48050

SOME COMPUTATIONAL AND EXPERIMENTAL ASPECTS OF OPTIMAL DESIGN PROCESS OF COMPOSITE STRUCTURES

STEVAN MAKSIMOVIC (Vazduhoplovnotehnicki Institut, Belgrade, Yugoslavia) (USAF and Paisley College of Technology, International Workshop on Optimum Design of Composite Structures, Glasgow, Scotland, July 27, 1989) Composite Structures (ISSN 0263-8223), vol. 16, no. 1-3, 1990, p. 237-258. refs Copyright

The paper is focused on developing efficient and reliable methods for structural analysis and weight optimization of complex composite structures by using numerical techniques. An automated procedure is presented for designing minimum weight composite structures by using finite element techniques subject to various types of constraint. Approximation concepts and dual methods are extended to solve structural synthesis problems of mechanically fastened composite joints in composites. In this consideration the characteristic curve together with the Yamada failure criterion, with earlier developed static strength, displacement and buckling are developed. Author

A90-48629

EDDY CURRENT DETECTION OF SUBSURFACE CRACKS

DONALD J. HAGEMAIER (Douglas Aircraft Co., Long Beach, CA) Materials Evaluation (ISSN 0025-5327), vol. 48, Sept. 1990, p. 1074-1076, 1078, 1079, 1081, 1082. Copyright

A nondestructive low-frequency (less than 10 kHz) eddy current inspection technique for detecting subsurface defects in aging aircraft is described. It is shown that, using this technique, subsurface cracks could be successfully detected in longerons located in the upper portion of the fuselage over the wings, in the aft pressure bulkhead tee caps, and in stringers located in the lower wing surface. The procedures applied to each of these cases are described in detail. I.S.

A90-48998

ANALYSIS OF FAILURES IN AIRCRAFT STRUCTURES

C. J. PEEL and A. JONES (Royal Aerospace Establishment, Farnborough, England) Metals and Materials (ISSN 0266-7185), vol. 6, Aug. 1990, p. 496-502. Copyright

Failure of a structural aircraft component can have catastrophic consequences, with the resulting loss of the whole aircraft and many lives. The investigation of defects and failures in aircraft structures is thus of vital importance in preventing aircraft disasters. This article uses detailed examples to illustrate the various methods used in the quantitative analysis of service failures in aircraft structures. Author

A90-49358

THERMAL PROTECTION SYSTEMS FOR HYPERSONIC TRANSPORT VEHICLES

G. REICH, J. HINGER, and M. HUCHLER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 11 p. refs (SAE PAPER 901306) Copyright

Thermal protection systems (TPS) for hypersonic transport vehicles are described and evaluated. During the flight through

the atmosphere moderate to high aerodynamic heating rates with corresponding high surface temperatures are generated. Therefore, a reliable light-weight but effective TPS is required, that limits the heat transfer into the central fuselage with the liquid hydrogen tank and that prevents the penetration of the temperature peak during stage separation to the load carrying structure. The heat transfer modes in the insulation are solid conduction, gas convection and radiation. Thermal protection systems based on different phenomena to reduce the heat transfer, like vacuum shingles, inert gas filled shingles, microporous insulations and multiwall structures, are described. It is demonstrated that microporous and multiwall insulations are efficient, light weight and reliable TPSs for future hypersonic transportation systems.

Author

A90-49469

A MODEL OF SMALL-DISTURBANCE WAVE IN LARGE-SCALE SEPARATION ZONE ASSOCIATED WITH STALL FLUTTER

SHENG ZHOU (Beijing University of Aeronautics and Astronautics, People's Republic of China) and SHIZHONG DUAN IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 206-212.

Copyright

A model is proposed which expresses the characteristics of the small-disturbance wave in the large-scale separated region associated with cascade stall flutter. The wake flow of the vibrating cascade may be composed of two parts: (1) an unsteady harmonic main flow corresponding to a vibrating cascade, and (2) a high-frequency pulsation corresponding to turbulent flow in the separation zone. The method presented shares some similarities with, but is in some respects different from, the large eddy simulation method.

O.C.

A90-49846#

THE BEHAVIOR OF ELECTRIC CURRENTS IN GRAPHITE/EPOXY STRUCTURES

E. CARL OLSON, EDWARD J. RUPKE (Beech Aircraft Co., Wichita, KS), J. ANDERSON PLUMER, and MICHAEL M. DARGI (Lightning Technologies, Inc., Pittsfield, MA) IN: 1988 International Aerospace and Ground Conference on Lightning and Static Electricity, Oklahoma City, OK, Apr. 19-22, 1988, Addendum to the Proceedings. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, p. 214-220. Research supported by Beech Aircraft Corp.

The electrical properties of graphite epoxy airframes are investigated based on testing of two generic structures: a wing section and a fuselage section. Induced transients of far greater time durations than previously expected are found. Relationships between structural voltages and currents are explored to identify relationships between structural resistance, wiring inductance and resistance, and magnetic field effects.

C.D.

N90-26819# PhotoStrain, Dallas, TX.

PHOTOELASTICITY: A COST EFFECTIVE DESIGN TOOL

JAN CERNOSEK IN AFWAL, Proceedings of the 1987 Aircraft/Engine Structural Integrity Program (ASIP/ENSIP) Conference p 640-646 Jun. 1988

Avail: NTIS HC A99/MF E06 CSCL 20/3

The great error of the past years was labeling a finite element (FE) method and three-dimensional photoelasticity as being two competing methods. Where finite element method works exceptionally well (thin walled airframe structures, for example), photoelasticity is nearly helpless but it excels in the area where FE has to use solid modeling which is time consuming, expensive and of questionable accuracy. Photoelasticity and finite element method should be considered to be complementary rather than competing methods of stress.

Author

N90-26899# General Electric Co., Schenectady, NY. Corporate Research and Development Center.

FLAME EXTINCTION IN COMPRESSIBLE FLOW Abstract Only
S. M. CORREA IN Sandia National Labs., Summary of Discussions at the Eleventh Meeting of the Sandia Cooperative Group on the Aerothermochemistry of Turbulent Combustion p 21 Oct. 1988
Avail: NTIS HC A03/MF A01

The structure of the compressible stagnation flow at the forward point of a cylinder in a uniform stream is examined. Such flows are used in the laboratory to characterize the structure and stability limits of counterflow diffusion flames, where the fuel is emitted radially from the surface of the cylinder against the uniform approach flow. While hydrocarbon fuels are extinguished at relatively low strain rates, corresponding to low approach velocities, hydrogen requires much larger strain rates for extinction. The corresponding approach flow is in the compressible range and requires analysis as such. Solutions and estimates are developed for the cases of subsonic and supersonic flow. In particular, a Rayleigh-Janzen expansion of the potential function is carried out to six terms, using a symbolic manipulation language, and the analytical results are differentiated to obtain the strain field in subsonic flow. Compressibility is shown to decrease the strain rate for constant approach velocity and cylinder radius. This counter-intuitive result is shown to be a near-field phenomenon due to higher-order singularities; the strain further upstream is shown to increase. Estimates made for the case of supersonic flow indicate a lower level of strain compared with that in subsonic compressible flow. These results indicate that compressibility of the free stream offers a potential for increased flame stability. The conclusions are relevant to flame stability in high-speed combustors, such as those in supersonic combustion ramjets.

Author

N90-27002# Rolls-Royce Ltd., Derby (England).

COST EFFECTIVE TECHNOLOGY

S. C. MILLER 4 Sep. 1989 24 p Presented at 9th ISABE, Athens, Greece, 4-9 Sep. 1989 Previously announced in IAA as A90-17447

(PNR90664; ETN-90-97150) Copyright Avail: NTIS HC A03/MF A01

With relation to advanced technology for gas turbines, the overall process of product definition and development, concentrating particularly on the integration of activities between engineering design and manufacturing, is surveyed. The development of new philosophies in each of these spheres of activity is concluded to be cost effective technology and to make a highly significant contribution to the competitiveness and profitability of the industry.

ESA

N90-27066*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN APPROXIMATE METHOD FOR CALCULATING THREE-DIMENSIONAL INVISCID HYPERSONIC FLOW FIELDS

CHRISTOPHER J. RILEY and FRED R. DEJARNETTE
Washington Aug. 1990 26 p
(NASA-TP-3018; L-16745; NAS 1.60:3018) Avail: NTIS HC A03/MF A01 CSCL 20/4

An approximate solution technique was developed for 3-D inviscid, hypersonic flows. The method employs Maslen's explicit pressure equation in addition to the assumption of approximate stream surfaces in the shock layer. This approximation represents a simplification to Maslen's asymmetric method. The present method presents a tractable procedure for computing the inviscid flow over 3-D surfaces at angle of attack. The solution procedure involves iteratively changing the shock shape in the subsonic-transonic region until the correct body shape is obtained. Beyond this region, the shock surface is determined using a marching procedure. Results are presented for a spherically blunted cone, paraboloid, and elliptic cone at angle of attack. The calculated surface pressures are compared with experimental data and finite difference solutions of the Euler equations. Shock shapes and profiles of pressure are also examined. Comparisons indicate the

method adequately predicts shock layer properties on blunt bodies in hypersonic flow. The speed of the calculations makes the procedure attractive for engineering design applications. Author

N90-27118# Universal Energy Systems, Inc., Dayton, OH.
SELF-LUBRICATING SURFACES BY ION BEAM PROCESSING
Final Report, 11 Aug. 1989 - 16 Mar. 1990
 RABI S. BHATTACHARYA Jun. 1990 34 p
 (Contract F33615-89-C-2944; AF PROJ. 3005)
 (AD-A222489; WRDC-TR-90-2044) Avail: NTIS HC A03/MF A01
 CSCL 20/7

The primary research objective of this work was to develop self-lubricating surface and coatings through direct ion implantations and a combined process of electron beam evaporation and ion implantation. The latter is most commonly referred in the literature as ion beam assisted deposition (IBAD). IBAD of a bi-layer coating of Calcium Fluoride/Silver on Silicon nitride resulted in a very adherent coating that exhibited significantly low friction and wear characteristic at both room and elevated temperatures (800 C). Ion beam assisted titanium dioxide coating on M50 steel showed significantly improved friction and wear characteristics at room temperature. Ion beam assisted Cadmium Oxide coating lowered the friction coefficient of M50 steel 400 C. The ion beam assisted deposition technique for fabricating self-lubricating surfaces appears to have good technical feasibility for defense and industrial applications, owing to the overall simplicity and scalability of the technique. The initial applications are likely to be in the seals and bearings of engines, variable stator vanes, etc., in gas turbine engine technology. GRA

N90-27120# Aeritalia S.p.A., Turin (Italy). Unita Efficacia del Sistema.
ESTIMATION OF DEFECTIVE RATE OF MECHANIC-HYDRAULIC COMPONENTS [STIMA DEL TASSO DI GUASTO PER COMPONENTI MECCANICO-IDRAULICI]
 R. BUFFARDI and S. CHIESA (Politecnico di Torino, Italy) 1988 8 p In ITALIAN; ENGLISH summary
 (Contract CNR-88-03287-07)
 (ETN-90-97275) Avail: NTIS HC A02/MF A01

The contributions made to an aircraft reliability and safety strategic programs are described. The defect rate of mechanical and hydraulic components is obtained as a function of the quality level and environmental conditions. The proposed analysis is confirmed by experimental data. The applications to aircraft design are discussed. ESA

N90-27629# Systems Control Technology, Inc., Palo Alto, CA.
EXPERT SYSTEM DIAGNOSTICS AND PARTS LIFE TRACKING AS APPLIED TO THE AV-8B AIRCRAFT FOR THE USMC
 JEFF FRENSTER, RONALD DEHOFF, and PAUL BRIGHT (Rolls-Royce Ltd., Bristol, England) In DLR, Aircraft Integrated Monitoring Systems p 261-274 Jan. 1990
 Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The F402 Engine Monitoring System (EMS) entered service on USMC (U.S. Marine Corps) AV-8B aircraft in February 1989. An expert system shell evaluates data recorded during the flight using rules developed for AV-8B maintenance support. Parts life tracking is based upon algorithms implemented in the EMS. Preliminary results indicate that the data processing ground station is becoming an integral part of the operational deployment of the AV-8B EMS. Future extensions of the system are considered. ESA

N90-27630# Scicon Consultancy International Ltd., London (England).
HARRIER INFORMATION MANAGEMENT SYSTEM (HIMS): THE SYSTEM AND THE APPROACH
 D. J. REYNOLDS In DLR, Aircraft Integrated Monitoring Systems p 275-292 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

The Harrier GR5 is to be fleet-fitted with an engine monitoring system. The ground station known as HIMS was developed to enable engineers to analyze parameter exceedance and component life count data collected from it. The HIMS and its development program are reviewed. Counts can vary from aircraft to aircraft for a given number of flying hours and lifting on this basis is expected to yield considerable savings. Aspects relevant to future aircraft health monitoring programs are considered. ESA

N90-27946*# Ohio State Univ., Columbus. ElectroScience Lab.
THE HELICOPTER ANTENNA RADIATION PREDICTION CODE (HARP) Final Report
 F. T. KLEVENOW, B. G. LYNCH, E. H. NEWMAN, R. G. ROJAS, J. T. SCHEICK, H. T. SHAMANSKY, and K. Y. SZE Aug. 1990 79 p
 (Contract NAG1-1058)
 (NASA-CR-186925; NAS 1.26:186925; FR-722792-1) Avail: NTIS HC A05/MF A01 CSCL 20/14

The first nine months effort in the development of a user oriented computer code, referred to as the HARP code, for analyzing the radiation from helicopter antennas is described. The HARP code uses modern computer graphics to aid in the description and display of the helicopter geometry. At low frequencies the helicopter is modeled by polygonal plates, and the method of moments is used to compute the desired patterns. At high frequencies the helicopter is modeled by a composite ellipsoid and flat plates, and computations are made using the geometrical theory of diffraction. The HARP code will provide a user friendly interface, employing modern computer graphics, to aid the user to describe the helicopter geometry, select the method of computation, construct the desired high or low frequency model, and display the results. Author

N90-27987# Technische Hochschule, Darmstadt (Germany, F.R.). Fachbereich Mathematik.
THE DISCRETIZATION OF THE THREE DIMENSIONAL BOUNDARY LAYER EQUATIONS Ph.D. Thesis [DIE DISKRETISIERUNG DER DREIDIMENSIONALEN GRENZSCHICHTGLEICHUNGEN]
 1988 96 p In GERMAN
 (ETN-90-97292) Avail: NTIS HC A05/MF A01

A discretization process of the stationary three dimensional incompressible laminar boundary layer equations is presented for a wing or a similar body. The solution was calculated at each point of the surface by an iteration algorithm. The appearing quadratic parts of the differential equation were linearized by the discretization. The continuity equation was integrated so that the velocity perpendicular to the wall does not appear explicitly; a discretization with finite elements was realized. ESA

N90-27999# Ecole Nationale Supérieure d'Arts et Metiers, Paris (France).
EFFICIENT SOLUTION OF THE STEADY EULER EQUATIONS WITH A CENTERED IMPLICIT METHOD
 A. LERAT and J. SIDES (Office National d'Etudes et de Recherches Aérospatiales, Paris, France) In VKI, Computational Fluid Dynamics, Volume 2 22 p 1990 Repr. from Numerical Methods for Fluid Dynamics 2 (Morton and Baines, Clarendon Press, Oxford, England), 1988 p 65-86
 Avail: NTIS HC A13/MF A02

A centered Euler solver is described, which is based on an implicit method of second order accuracy and can approximate steady weak solutions without artificial viscosity. The method is presented in one space dimension and extended to two dimensions. The accuracy obtained at steady state is discussed. Applications to transonic aerodynamics concerning the internal flow in a channel with a bump and several external flows over an airfoil at low and high angles of attack are given. The efficiency and the

shock-capturing capabilities of the method are demonstrated.

ESA

N90-28059# Oak Ridge National Lab., TN.

ENGINE TESTING OF THERMOGRAPHIC PHOSPHORS

K. W. TOBIN, M. R. CATES, D. L. BESHEARS, J. D. MUHS, G. J. CAPPS, D. B. SMITH, W. D. TURLEY, W. LEWIS, B. W. NOEL, H. M. BORELLA (Los Alamos National Lab., NM.) et al. May 1990 17 p

(Contract DE-AC05-84OR-21400)

(DE90-013269; ORNL/ATD-31) Avail: NTIS HC A03/MF A01

A thermographic phosphor technique is being developed for nonintrusive high temperature analysis of the hostile environments associated with turbomachinery. This unique noncontact measurement system will eventually be applied to high-speed, rotating surfaces whose direct analysis has been unobtainable with current temperature-sensing devices and systems. Two experiments are reported which involve static surface temperature measurements in a Pratt and Whitney PW2037 turbine engine, and dynamic surface temperature measurements in a Pratt and Whitney JT15D turbofan jet engine. The thermographic phosphor materials applied to these engine environments were europium-doped yttrium oxide and europium-doped yttrium vanadate. The excitation energy was supplied by a tripled neodymium YAG laser at 355 nm. DOE

N90-28068# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

IMPACT OF EMERGING NDE-NDI METHODS ON AIRCRAFT DESIGN, MANUFACTURE, AND MAINTENANCE

May 1990 232 p In ENGLISH and FRENCH The 69th meeting held in Brussels, Belgium, 1-6 Oct. 1989

(AGARD-CP-462; ISBN-92-835-0546-8) Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Developments in NDE-NDI (nondestructive evaluation-nondestructive inspection) applicable to the major components and assemblies in airframes, engines, and their sub-assemblies were reviewed. Users' needs and priorities were discussed with emphasis on identification of the constraints that present day NDE-NDI methods impose on the activities of aircraft designers/manufacturers, airworthiness authorities, and aircraft operators. The methods available for the characterization and control of materials and processes were examined and current developments in techniques for improved reliability and in-service inspection were assessed. In a final session, research studies in both physical and analytical methods were reviewed.

N90-28072# Royal Aerospace Establishment, Farnborough (England). Dept. of Materials and Structures.

INSPECTION RELIABILITY

DAVID A. BRUCE In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 10 p May 1990

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The current methods for estimating the reliability of nondestructive evaluation (NDE) procedures are briefly reviewed. As an example, their application to the results of a recent UK-led baseline study of the reliability of rotating probe eddy current inspection, is described. After introducing definitions of the terminology, the proposed parametric and non-parametric statistical methodologies are described. The result of applying these methodologies to the actual results of the baseline program is shown, while the implications of the findings are examined in terms of their impact on airworthiness calculations, and the improvements which may be necessary if more reliance is to be placed on estimates of NDE reliability. Author

N90-28076# Aeritalia S.p.A., Turin (Italy). Defence Aircrafts Group.

AN ULTRASONIC SYSTEM FOR IN-SERVICE NON-DESTRUCTIVE INSPECTION OF COMPOSITE STRUCTURES

F. BOSCHETTI, F. CIPRI, L. PUGLIESE, and M. SCOLARIS In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 6 p May 1990

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In order to perform, directly on the airfield, the nondestructive inspection (NDI) of aerospace composite structures by means of equipment similar to that already in use in the manufacturing workshop, a new ultrasonic system was developed by Aeritalia. The system includes an ultrasonic telemetry device for the geometrical location of the U.S. transducer position on the structure to be scanned and an instrumentation for the acquisition and processing of the ultrasonic data by B or C scan representation. The system operates in pulse-echo mode and provides in real-time a bidimensional representation of the intensity of the U.S. signals as well as the depth of the reflecting surface. Some typical examples of inspection performed on composite primary structures during fatigue tests simulating service life are presented. Author

N90-28078# Universal Technology Corp., Dayton, OH.

IN-SERVICE INSPECTION OF COMPOSITE COMPONENTS ON AIRCRAFT AT DEPOT AND FIELD LEVELS

NOEL A. TRACY, GROVER L. HARDY, and FRANK J. FECHEK (Wright Research Development Center, Wright-Patterson AFB, OH.) In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 11 p May 1990

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ARIS (Automated Real-Time Imaging System) is a modular, easily transportable, field-ready, ultrasonic system that provides automated, simultaneous recording and real-time display of ultrasonic data and search-unit position during routine manual inspections of laminar and sandwich aircraft structures. The Materials Laboratory of the U.S. Air Force Wright Research and Development Center sponsored the development of ARIS and subsequently evaluated the system in both laboratory and field environments with the aid of an independent contractor. During the evaluation ARIS was used on many aircraft structural components to determine if the system operated according to specifications and to discover ways of improving its applicability and usefulness. Suggested modifications addressed new applications of ARIS, the convenience and comfort of using ARIS, and the appropriateness and logicity of the software. Apart from its use on aircraft parts, ARIS was evaluated for transportability, ease of set-up, operational defects, and hardware reliability. Pictorial examples of ARIS in use are included and all aspects of the field evaluation are discussed. The versatility of ARIS is evident through the many features in the original design and the seemingly minor modifications in hardware and software that enhanced the features so that ARIS turned out to be more widely applicable than originally planned. ARIS has a definite place in the portable C-scan arena. Author

N90-28079# Defence Research Establishment Pacific, Victoria (British Columbia).

DEVELOPMENT OF AN AUTOMATED ULTRASONIC INSPECTION SYSTEM FOR COMPOSITE STRUCTURE ON IN-SERVICE AIRCRAFT

W. R. STURROCK, R. W. RAMSBOTTOM, and W. J. MILLER (National Defence Headquarters, Ottawa, Ontario) In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 13 p May 1990

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Composite honeycomb (carbon/epoxy facesheets bonded to

aluminum honeycomb) control surfaces for the CF-18 are inspected at the time of manufacturing using (among other methods) ultrasonic through-transmission, but there is no automated ultrasonic inspection system to verify structural integrity of the honeycomb on in-service aircraft. Manual methods of ultrasonic contact scanning or even local through-transmission can be performed over small areas, but it is impossible to reliably inspect a complete control surface, such as a trailing edge flap on the wing or a horizontal stabilizer, with hand-held transducers. A description is given of the development and characteristics of an automated scanner and ultrasonic system to perform through-transmission inspections of honeycomb structure on the CF-18 without removal of the part from the aircraft. The prototype system, including a mobile lift table/platform, was demonstrated on an aircraft at CFB Cold Lake, Alberta, and examples of C-scan images obtained are shown. Recommendations are made for further improvements. Author

N90-28080# Industrieranlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).

NEUTRON RADIOGRAPHY: APPLICATIONS AND SYSTEMS

H.-U. MAST and R. SCHUETZ /in AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 11 p May 1990 Sponsored by Federal Ministry of Research and Development, Fed. Republic of Germany Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In accordance with previous results obtained in the U.S., a recent research project showed neutron radiography to be a nondestructive testing (NDI) method of potential value in aerospace maintenance and quality assurance, complementing conventional inspection methods. Applications include the detection of corrosion products, entrapped moisture, adhesive defects as well as some defects in carbon fiber composites. For years the large-scale use of neutron radiography was delayed due to the lack of small and inexpensive but powerful neutron sources. Recent progress in this area led to the present development of a new generation of small neutron sources, such as compact cyclotrons and powerful neutron generators. Author

N90-28082# Royal Military Coll. of Canada, Kingston (Ontario). Dept. of Physics.

ACOUSTIC EMISSION DETECTION OF CRACK PRESENCE AND CRACK ADVANCE DURING FLIGHT

S. L. MCBRIDE, M. D. POLLARD, J. D. MACPHAIL, P. S. BOWMAN, and D. T. PETERS /in AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 5 p May 1990 Sponsored by Department of National Defence, Ottawa, Ontario

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Results are presented which show that it is possible to detect crack growth and crack presence in airframe composites during flight. To accomplish this, a data acquisition system was developed specifically for in-flight applications. It is shown that crack advance of less than 1 sq mm was readily detected during flight and the fracture-related acoustic emission signals. Author

N90-28084# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).

THE APPLICATION OF INFRARED THERMOGRAPHY TO THE NONDESTRUCTIVE TESTING OF COMPOSITE MATERIALS [APPLICATION DE LA THERMOGRAPHIE INFRAROUGE AU CONTROLE NON DESTRUCTIF DES MATERIAUX COMPOSITES]

HERVE TRETOUT, JEAN-YVES MARIN, and RENE DEMOL /in AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 8 p May 1990 In FRENCH Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The construction of the structural parts in composite materials for aircraft necessitated the development of some way to test more, in order to assure the quality of the finished product. This testing must take place before assembly of the aircraft and in ground time or upon disassembly at the factory. Different methods of nondestructive tests, as well as testing by ultrasound and by x radiography are already widely used. However, the need for a faster and easier test, stimulates the development of infrared thermography. Transl. by E.R.

N90-28085# Institut Foerster G.m.b.H. und Co. K.G., Reutlingen (Germany, F.R.).

NEW ASPECTS IN AIRCRAFT INSPECTION USING EDDY CURRENT METHODS

MANFRED TIETZE /in AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 8 p May 1990

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High demands in safety at the highest possible load of aircraft structures cause increasing expenditure in the development of testing procedures for production, maintenance, and overhaul. Aircraft structural parts which are generally designed to achieve minimum weight as well as high mechanical stability unfortunately very often have the disadvantages of low corrosion resistance and high susceptibility to crack formation and propagation. Consequently the latitude for tolerable flaw sizes is very small. Therefore, reliable, documented inspection is of increasingly vital importance. Eddy current testing is one of the most effective tools to detect open or concealed corrosion and to assess damage caused by fatigue or corrosion cracking. In respect of the different sources of corrosion and possible crack formation, to enable identification, evaluation, and location it is necessary to have appropriate eddy current units and sensors optimized to the expected inspection program. The following describes the use of a meter type instrument for inspection of surface defects and a new impedance plane instrument that allows static and dynamic applications for detection of metal thinning due to corrosion, metal spacing, subsurface cracks, etc. and for very quick fastener hole inspection. Finally, new signal processing techniques for displaying flaw dimensions through imaging procedures are discussed. All units described are portable and battery operated. Author

N90-28088*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ADVANCED NDE TECHNIQUES FOR QUANTITATIVE CHARACTERIZATION OF AIRCRAFT

JOSEPH S. HEYMAN and WILLIAM P. WINFREE /in AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 13 p May 1990

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Recent advances in nondestructive evaluation (NDE) at NASA Langley Research Center and their applications that have resulted in quantitative assessment of material properties based on thermal and ultrasonic measurements are reviewed. Specific applications include ultrasonic determination of bolt tension, ultrasonic and thermal characterization of bonded layered structures, characterization of composite materials, and disbonds in aircraft skins. Author

N90-28091# Aerospatiale, Suresnes (France). Central Lab.

INSPECTION SYSTEM FOR IN-SITU INSPECTION OF AIRCRAFT COMPOSITE STRUCTURES

P. BLONDET and I. MOLINERO /in AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 8 p May 1990

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The intensive use of composite materials in aircraft primary

structures has led to the setting up of special inspection systems for the detection of any defects which may be produced during the life of the aircraft. The main defects which are investigated during maintenance are, in general, delamination defects produced by various types of impact (stones, lightning, effects of maintenance tools being dropped). Until more global techniques (thermography, holography) are developed, the most suitable method for this type of inspection is ultrasonics. The problem involves application of these inspection procedures to an aircraft under maintenance conditions while scanning the areas to be inspected and obtaining a real time diagnosis. The SIAM R-theta system was especially designed to meet the requirements of this type of inspection. It is capable of both assessing the damage after detection of the defect (visually, for example), and detecting defects within the framework of general inspection. Author

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USE OF ACOUSTIC EMISSION FOR CONTINUOUS SURVEILLANCE OF AIRCRAFT STRUCTURES

M. NABIL BASSIM /In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 6 p May 1990 Sponsored in part by Petro-Canada Ltd., Calgary, Alberta; Ontario Hydro; Viatex Resources; Canadian Natural Sciences and Engineering Research Council; and National Research Council of Canada Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Since its inception as a technique of nondestructive evaluation, acoustic emission (AE) has held great promise for its ability to provide monitoring of structures on a continuing basis. Equipment development, however, has emphasized periodic testing and a lack of adaptation to the specific conditions of a given structure, such as aircraft, in terms of operating conditions, noise, vibration, etc. Because of these factors, the use of acoustic emission for continuous monitoring of aircraft structures has been lacking. Recently, the problem was approached from two angles. Firstly, a predictive approach was developed for using acoustic emission to monitor fracture and fatigue of materials. In this approach, the relationship between acoustic emission and fatigue life (expressed as stress intensity factor or the number of cycles to failure) is defined both theoretically and experimentally. It is then possible, using techniques of dynamic pattern recognition, to obtain the status of a structure with respect to its remaining life. Acoustic emission maps for different materials failing by fatigue are produced. Secondly, a new acoustic emission system was patented which relies on using intelligent and expert systems software, as well as rule for defining fatigue damage. The combination of these two approaches produces a significant development in using acoustic emission for continuous monitoring of aircraft and other structures and fulfills the promise held by AE in that direction. Author

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IMPACT OF NDE-NDI METHODS ON AIRCRAFT DESIGN, MANUFACTURE, AND MAINTENANCE, FROM THE FUNDAMENTAL POINT OF VIEW

LEONARD J. BOND /In AGARD, Impact of Emerging NDE-NDI Methods on Aircraft Design, Manufacture, and Maintenance 5 p May 1990 Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Comments are presented on the impact of emerging NDE-NDI (nondestructive evaluation-nondestructive inspection) methods on aircraft design, manufacture, and maintenance. In particular, fundamental aspects of recent developments are considered, together with current trends and future prospects. The meeting presentations and discussion are reviewed in terms of the philosophy, physics, and technology involved. NDE-NDI is shown to require consideration as an integral part of the design, manufacturing, and operational condition monitoring process, for

all parts of an aircraft. Various areas of NDE are highlighted and these include the importance of high performance quantitative NDE, the impact of new materials (e.g., composites), changes in manufacturing processes (e.g., diffusion bonding), and the importance of mathematical modeling for inspection optimization and also for the identification of NDE inspection techniques. Automation of the implementation of NDT and both the recording and the display of the resulting data is seen to be necessary in many cases to achieve the required sensitivity and level of reliability of inspection. Global inspection techniques are being sought which highlight suspect zones that can then be investigated using other techniques, to provide detailed local examinations. Author

N90-28105*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.

THERMAL STRUCTURES: FOUR DECADES OF PROGRESS

Final Report, period ending 31 Dec. 1989

EARL A. THORNTON Aug. 1990 25 p Previously announced in IAA as A90-29305

(Contract NSG-1321)

(NASA-CR-186898; NAS 1.26:186898) Avail: NTIS HC A03/MF A01 CSCL 20/11

Since the first supersonic flight in October 1947, the United States has designed, developed and flown flight vehicles within increasingly severe aerothermal environments. Over this period, major advances in engineering capabilities have occurred that will enable the design of thermal structures for high speed flight vehicles in the twenty-first century. Progress in thermal-structures is surveyed for the last four decades to provide a historical perspective for future efforts. Author

N90-28106# McDonnell Aircraft Co., Saint Louis, MO.

DAMAGE TOLERANCE ANALYSIS FOR MANNED HYPERVELOCITY VEHICLES. VOLUME 1: FINAL TECHNICAL REPORT Report, Sep. 1986 - Sep. 1989

D. M. HARMON and C. R. SAFF Sep. 1989 178 p (Contract F33615-86-C-3208; AF PROJ. 2401)

(AD-A221970; WRDC-TR-89-3067-VOL-1) Avail: NTIS HC A09/MF A01 CSCL 20/11

The objective of this program was to provide a fracture mechanics based life prediction procedure for hypersonic airframe structures subjected to combined mechanical loadings and thermal profiles. Existing routines were used along with element test data to develop this procedure. The accuracy of the procedure was determined by predicting the crack growth under thermomechanical load histories typical of advanced fighters and aerospace vehicles, and then comparing those predictions with test results. Limitations in the ability of this procedure to predict the test results were used to formulate recommendations for further modeling efforts and research. A fracture mechanics based life prediction procedure was developed for hypersonic airframes subjected to thermomechanical load profiles. The analysis that was developed models crack growth behavior in metals, accounts for the effects of temperature on yield strength and fracture toughness, and includes the effects of sustained loads at elevated temperature on crack growth rate. The analysis was incorporated into a computer routine named DAMAGE. Predictions made with the DAMAGE routine were within 20 percent of the test lives for 67 percent of the combined thermomechanical load history tests performed. GRA

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A90-47572

AIRCRAFT MEASUREMENTS OF SEA SURFACE CONDITIONS AND THEIR RELATIONSHIP TO MARINE BOUNDARY-LAYER DYNAMICS

AIME DRUILHET, PIERRE DURAND, ALBERTE FISCHER, and FREDERIQUE SAID (Toulouse III, Universite, France) *Boundary-Layer Meteorology* (ISSN 0006-8314), vol. 52, no. 4, Sept. 1990, p. 397-414. Research supported by INSU. refs Copyright

A90-48351

ANALYSIS AND PREDICTION OF WEATHER FOR AVIATION [ANALIZ I PROGNOZ POGODY DLIA AVIATSI]

K. G. ABRAMOVICH, ED. and A. A. VASIL'EV, ED. Leningrad, Gidrometeoizdat (Gidrometeorologicheskii Nauchno-Issledovatel'skii Tsentr SSSR, Trudy, No. 305), 1989, 184 p. In Russian. For individual items see A90-48352 to A90-48364. Copyright

The papers contained in this volume provide an overview of recent research aimed at the development of methods for diagnosing and predicting meteorological conditions for aviation. Topics discussed include the characteristics of vortex forcing and vertical circulation in a layer of jet flows; consideration of pressure and wind field adaptation in calculating wind velocity over airfields; an automated method for predicting the height of the lower cloud boundary; and using the potential vortex for calculating the tropopause height and temperature. Papers are also presented on conditions of the formation of tornados and recommendations for their prediction and using cloud moisture calculations for estimating the intensity of aircraft icing. V.L.

A90-48358

USING CLOUD MOISTURE CALCULATIONS FOR ESTIMATING AIRCRAFT ICING [ISPOL'ZOVANIE RASCHETNOI VODNOSTI OBLAKOV DLIA OTSENKI INTENSIVNOSTI OBLEDENENIIA VOZDUSHNYKH SUDOV]

I. A. GORLACH IN: Analysis and prediction of weather for aviation. Leningrad, Gidrometeoizdat, 1989, p. 76-85. In Russian. refs Copyright

A90-48359

AN AUTOMATED METHOD FOR PREDICTING THE HEIGHT OF THE LOWER CLOUD BOUNDARY [AVTOMATIZIROVANNYI METOD PROGNOZA VYSOTY NIZHNEI GRANITSY OBLAKOV]

N. N. GUSEVA and M. V. RUBINSHEIN IN: Analysis and prediction of weather for aviation. Leningrad, Gidrometeoizdat, 1989, p. 86-97. In Russian. refs Copyright

The principles of the objective classification of synoptic processes with allowance for low cloud formation and evolution are discussed with reference to cloud forecasting. A procedure for forecasting the height of the lower cloud boundary for periods of 1-3 and 6 hr, used at airfields around Moscow, is described. A technique is proposed for approximating the probability distribution of low cloud boundary heights that are greater or less than the predicted value. The possibility of representing forecasts in alternative and probability forms is demonstrated, and the accuracy of these forecasts is compared with that of inertial and climatic forecasts. V.L.

A90-48362

VERTICAL WIND SHEARS IN LOWER-LEVEL JET STREAM OVER SOME AIRFIELDS IN THE URALS AND SIBERIA [VERTIKAL'NYE SDVIGI VETRA V STRUINYKH TECHENIIAKH NIZHNIKH UROVNEI NAD NEKOTORYMI AERODROMAMI URALA I SIBIRI]

V. G. GLAZUNOV and T. V. DAVIDOVICH IN: Analysis and prediction of weather for aviation. Leningrad, Gidrometeoizdat, 1989, p. 130-137. In Russian. refs Copyright

A90-48364

SOME CHARACTERISTICS OF THE METEOROLOGICAL CONDITIONS OF LOW CLOUD FORMATION AROUND THE BAKU AIRPORT [NEKOTORYE KHARAKTERISTIKI METEOROLOGICHESKIKH USLOVII POIAVLENIIA NIZKIKH OBLAKOV V RAIONE AEROPORTA BAKU]

N. SH. GUSEINOV IN: Analysis and prediction of weather for aviation. Leningrad, Gidrometeoizdat, 1989, p. 157-170. In Russian. refs Copyright

A90-49826

1988 INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY, OKLAHOMA CITY, OK, APR. 19-22, 1988, ADDENDUM TO THE PROCEEDINGS

Conference organized by NOAA. Boulder, CO, National Oceanic and Atmospheric Administration, 1988, 276 p. For individual items see A90-49827 to A90-49848.

Various papers on lightning and static electricity are presented. The general topics addressed include: aircraft strike statistics, lightning propagation models, Atlas Centaur incident and aerospace vehicles, lightning parameter measurements, launch support, lightning fields and currents, flight data and instrumentation, simulation and testing, aircraft electric fields and triggered lightning, P-static and electrostatic discharges, rocket-triggered ground strikes, safety and medical effects, warning ground facilities, thunderstorm studies, protection ground facilities, aircraft analysis, lightning detection and mapping systems, effects on systems, and lightning strike mapping systems. C.D.

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-46001

DECENTRALIZED SYSTEMS

IVAN P. POPCHEV Sofia, Publishing House of the Bulgarian Academy of Sciences, 1989, 279 p. refs Copyright

The decentralized stabilization and optimization of linear interconnected systems are considered theoretically and demonstrated. Chapters are devoted to the fundamental principles of decentralized control (DCC), the formulation of DCC design problems, design methods for continuous-time systems, design methods for discrete-time systems, and a machine-independent software package developed for DCC linear-systems design. A number of practical applications of DCC are described, including the frequency-control problem for a MW electric-power system, an evaporation process, a distillation column, a generic traffic network, and a simplified flight controller. Also discussed is the problem of DCC in the presence of uncertainties. T.K.

A90-46046

MULTICRITERIA OPTIMAL LAYOUTS OF AIRCRAFT AND SPACECRAFT STRUCTURES

G. KNEPPE (MBB GmbH, Munich, Federal Republic of Germany)
 IN: Multicriteria design optimization: Procedures and applications.
 Berlin and New York, Springer-Verlag, 1990, p. 229-243. refs
 Copyright

The application of multicriteria approach to aircraft and space structures is illustrated on two examples - a composite fin of an advanced supersonic aircraft and a satellite structure. An optimization procedure consisting of optimization algorithms, optimization models, and structural analysis including sensitivity analysis is presented. The theoretical foundations of aeroelasticity and heat transfer are discussed. It is found that an objective conflict occurs between the fin structural weight and the aeroelastic efficiency, while the heat flux and natural frequency are found to be competing objectives for the satellite. The optimization strategies presented in the study are used for transforming the multicriteria optimization problems into scalar substitute problems, and the proposed optimization procedure is employed to solve these resulting problems. V.T.

A90-46960#

RECENT DEVELOPMENTS IN ROTOR DYNAMICS METHODOLOGY IN THE U.S. INDUSTRY

ROBERT SOPHER (Sikorsky Aircraft, Stratford, CT) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 19 p. refs

Recent developments in rotor dynamics methodology in the U.S. industry are reviewed. Newly developed or modified analyses and their capabilities are discussed, including the development of new rotor dynamic analyses based to varying degrees on substructure decomposition of the dynamical system, the application of software development methodology, and introduction of executive based systems. Progress is reported in the development and validation of codes which address the need to handle configurations of increased complexity relative to the first generation codes. It is noted that the high cost of developing and validating new codes has led manufacturers to use prevalidated older codes to complement new codes. Recent university developments are reviewed and it is noted that universities have apparently advanced beyond industry in the development of finite element based codes applicable to composite materials and have applied these to a variety of problems to predict loads and stability. A series of diagrams and comprehensive explanatory graphs are included. L.K.S.

A90-46963#

DEVELOPMENT OF THE SECOND GENERATION COMPREHENSIVE HELICOPTER ANALYSIS SYSTEM (2GCHAS)

WENDELL B. STEPHENS, MICHAEL J. RUTKOWSKI, ROBERT A. ORMISTON, and CARINA M. TAN (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS National Specialists' Meeting on Rotorcraft Dynamics, Arlington, TX, Nov. 13, 14, 1989, Proceedings. Alexandria, VA, American Helicopter Society, 1989, 26 p. refs

The U.S. Army has initiated the development of a large, multidisciplinary, computer software system designed to analyze the performance, stability and control, aeroelastic stability, loads and vibration, and aerodynamics characteristics of rotorcraft. When complete, the Second Generation Comprehensive Helicopter Analysis System (2GCHAS) will become the foundation for future Army comprehensive analytical developments. This paper reviews first generation rotorcraft analysis systems, provides a technical description of 2GCHAS, and describes the program objectives, the project management approach, the methodology used in the development of the system, and the system integration and engineering validation phases of the 2GCHAS Project. The paper concludes with a summary of the lessons learned during the development of the 2GCHAS. Author

A90-47606*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

STRUCTURAL MODE SIGNIFICANCE USING INCA

FRANK H. BAUER, JOHN P. DOWNING (NASA, Goddard Space Flight Center, Greenbelt, MD), and CHRISTOPHER J. THORPE (Fairchild Space Co., Germantown, MD) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 285-294. refs
 (AIAA PAPER 90-3346) Copyright

Structural finite element models are often too large to be used in the design and analysis of control systems. Model reduction techniques must be applied to reduce the structural model to manageable size. In the past, engineers either performed the model order reduction by hand or used distinct computer programs to retrieve the data, to perform the significance analysis and to reduce the order of the model. To expedite this process, the latest version of INCA has been expanded to include an interactive graphical structural mode significance and model order reduction capability. Author

A90-47669#

OPTIMAL SOLUTIONS TO FLIGHT MECHANICS PROBLEMS USING A NONLINEAR PROGRAMMING AND COLLOCATION TECHNIQUE

HAI N. NGUYEN (Aerospace Corp., El Segundo, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 911-922. refs
 (AIAA PAPER 90-3415) Copyright

A study was conducted to examine the feasibility of using the Nonlinear Programming and Collocation technique to solve a wide range of problems frequently encountered in flight mechanics. First proposed by Dickmanns and Wells as an indirect method, the technique uses third order Hermite polynomials to approximate trajectory parameters in each segment of a trajectory. A direct method based on the technique was later developed by Hargraves and Paris. Optimal solutions are obtained by varying the function values of trajectory parameters at nodes delimiting a segment and the control coefficients so that checkpoint errors located at the center of a segment plus terminal and path constraint errors are driven to zero. The technique has been implemented in a FORTRAN computer program named FONPAC (Flight Optimization with Nonlinear Programming and Collocation) and it has been used to solve various ascent trajectory problems in which different levels of formulation complexity are considered. The results of these examples have validated the program logic and demonstrated the usefulness and versatility of the technique. Author

A90-47688*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ARTIFICIAL INTELLIGENCE (AI) BASED TACTICAL GUIDANCE FOR FIGHTER AIRCRAFT

JOHN W. MCMANUS and KENNETH H. GOODRICH (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1079-1087. refs
 (AIAA PAPER 90-3435) Copyright

A research program investigating the use of artificial intelligence (AI) techniques to aid in the development of a Tactical Decision Generator (TDG) for Within Visual Range air combat engagements is discussed. The application of AI programming and problem solving methods in the development and implementation of the Computerized Logic For Air-to-Air Warfare Simulations (CLAWS), a second generation TDG, is presented. The knowledge-based systems used by CLAWS to aid in the tactical decision-making process are outlined in detail, and the results of tests to evaluate the performance of CLAWS versus a baseline TDG developed in FORTRAN to run in real time in the Langley Differential Maneuvering Simulator, are presented. To date, these test results have shown significant performance gains with respect to the TDG baseline in one-versus-one air combat engagements, and the

AI-based TDG software has proven to be much easier to modify and maintain than the baseline FORTRAN TDG programs.

Author

A90-47690*# Princeton Univ., NJ.

PROBABILISTIC REASONING FOR INTELLIGENT WIND SHEAR AVOIDANCE

D. ALEXANDER STRATTON and ROBERT F. STENGEL (Princeton University, NJ) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1099-1107. refs

(Contract NAG1-834)

(AIAA PAPER 90-3437) Copyright

A computerized intelligent cockpit aid can increase flight-crew awareness of wind shear, improving avoidance decisions. The FAA Windshear Training Aid (WTA) provides guidelines for assessing the risk of wind shear encounter from meteorological evidence. Use of these guidelines in the cockpit is complicated by uncertainty surrounding meteorological knowledge of wind shear. Bayesian network representation is discussed as a means of modeling this uncertain knowledge in a computer. A probabilistic model of the WTA guidelines using Bayesian network representation is presented. This model combines evidence from sources of varying reliability and incorporates results from meteorological studies of wind shear. The probabilistic model can provide flight crews with meaningful estimates of risk to aid their decisions, using evidence from a variety of sources and a base of meteorological knowledge.

Author

A90-47697*# Arizona State Univ., Tempe.

EXTENDED IMPLICIT MODEL FOLLOWING AS APPLIED TO INTEGRATED FLIGHT AND PROPULSION CONTROL

DAVID K. SCHMIDT and JOHN D. SCHIERMAN (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1159-1169. refs

(Contract NAG3-998)

(AIAA PAPER 90-3444) Copyright

An extended model-following control-synthesis method, including loop-transfer recovery, is presented and applied to synthesize control laws for integrated flight and propulsion control (IFPC). The vehicle considered is representative of an unstable modern fighter aircraft; with a two-dimensional thrust-vectoring and thrust-reversing nozzle. The linearized design model includes both airframe and engine dynamics. A model-following formulation of the LQR problem is extended to handle this hybrid problem. Compensators are then obtained to realize an output-feedback control law, by using a loop-transfer-recovery procedure. The airframe and engine responses are decoupled, and perfect airframe response following is obtained. The loop transfers also reveal good stability robustness and reasonable loop cross-over frequencies that would not lead to excessive actuation requirements.

Author

A90-47698#

ROBUSTNESS EVALUATION OF A FLEXIBLE AIRCRAFT CONTROL SYSTEM

MARK R. ANDERSON (Systems Control Technology, Inc., Lexington Park, MD) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1170-1179. refs

(AIAA PAPER 90-3445) Copyright

The structured singular value analysis technique is used to generate stability and performance robustness guidelines for multivariable, flexible aircraft flight control systems. A stability augmentation and structural mode control system, designed using the same classical technique as on the original production aircraft, is evaluated to produce the new guidelines. Stability margins are computed for simultaneous gain and phase uncertainty in each of the control system feedback loops. Performance weighting filters are chosen specifically from military flying qualities specifications.

The results of this research define exactly how robust a control system of this type should be, such that any performance improvements achieved using more advanced design techniques can be compared directly.

Author

A90-47699*# Arizona State Univ., Tempe.

MULTIVARIABLE FLIGHT CONTROL SYNTHESIS AND LITERAL ROBUSTNESS ANALYSIS FOR AN AEROELASTIC VEHICLE

DAVID K. SCHMIDT and BRETT NEWMAN (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1180-1189. refs

(Contract NAG1-758)

(AIAA PAPER 90-3446) Copyright

An integrated flight/aeroelastic control law is developed analytically for a hypothetical large supersonic transport aircraft in which the first aeroelastic mode frequency of the fuselage (6 rad/sec) is near the short-period mode (2 rad/sec). The approach employed is based on a linear-quadratic-regulator (LQR) formulation (yielding model-following state-feedback gains), followed by asymptotic loop-transfer recovery of LQR robustness (to produce an output-feedback control law). The derivation is outlined, and numerical results comparing the performance and multivariate stability robustness of the present controller with those of a classical controller are presented in graphs. The two controllers are shown to have similar characteristics, even with respect to the sources of limitations on robustness.

T.K.

A90-47706#

LOCAL ADAPTIVE MANEUVERING OPTIMIZATION FOR FIGHTER AIRCRAFT

NEAL CONRARDY, S. JOHNNY FU (Boeing Military Airplanes, Wichita, KS), and TIMOTHY BARON (Boeing Computer Services, Wichita, KS) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1252-1258. refs

(AIAA PAPER 90-3453) Copyright

A local adaptive maneuvering optimization (LAMO) algorithm for one-to-one air combat is described. The local optimization technique uses a unique window reducing method to determine an optimal control set for each time step in the simulation. The algorithm is compared with NASA's Adaptive Maneuvering Logic (AML) and shows a considerable improvement. The examples presented only compare the aggressive modes of the LAMO algorithm with the AML algorithm. Both algorithms assume complete state information on each other. The method used to compare the two algorithms does not use a probabilistic measure but it is shown the method is valid for the comparison. The LAMO algorithm is a very robust and versatile algorithm since its cost function can easily be changed to reflect many conditions, i.e. missile evasion and weapons delivery. The results presented are based on preliminary development and further refinements will enhance the performance of LAMO.

Author

A90-47723#

MODEL REDUCTION WITH A FINITE-INTERVAL H(INFINITY) CRITERION

M. B. SUBRAHMANYAM and MARC STEINBERG (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1419-1427. refs

(AIAA PAPER 90-3473)

The problem of reducing the complexity of the plant model in the design of an optimal controller such as an aircraft flight-control system is investigated analytically. The approach is based on the sufficient condition derived by Tadmor (1990) for reduced-order models satisfying both an optimized L2 bound and a prespecified H(infinity) bound and expressed in terms of solutions of four coupled

Riccati equations. The computation of λ for a given reduced-order model is explained; the robustness of the reduction is explored; and numerical results are presented in graphs for two simple examples (a stable and an unstable second-order system) and for the eighth-order longitudinal system of the Advanced Supersonic Transport (including the first and second fuselage bending modes). The potential use of the present algorithm to fine-tune reduced-order models obtained by other methods (e.g., spectral decomposition) is briefly considered. T.K.

A90-47725#

A NEW METHODOLOGY FOR MODEL ORDER REDUCTION WITH APPLICATION TO EIGENSTRUCTURE CONTROLLERS

ESMAT BEKIR and HUSSEIN YOUSSEF (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1439-1449. refs (AIAA PAPER 90-3475) Copyright

A technique based on singular-perturbation theory is developed to reduce the order of aircraft dynamical models and thus facilitate control-system design. The fundamental principles of the singular-perturbation method (SPM) are reviewed; two derivative methods based on the SPM are outlined, summarizing the results of Bekir (1989); and the application of the SPM to the flexible-body model of the Advanced Supersonic Transport (AST) is described in detail. Particular attention is given to the AST open-loop frequency response, tradeoff aspects of the SPM, the value of the SPM in eigenstructure-assignment feedback-control design, and closed-loop feedback control of the AST. Simulation results are presented in extensive tables and graphs and briefly characterized. The SPM predictions are found to be in better agreement with the full-order AST model than those obtained with other methods (spectral decomposition, simultaneous gradient error reduction, balancing, or asymptotic balancing). T.K.

A90-47730#

SYNTHESIS OF A SIMULATOR-BASED AUTOMATED HELICOPTER HOVER TRAINER

K. KRISHNAKUMAR, J. E. BAILEY (Alabama, University, Tuscaloosa), J. DOHME (U.S. Army, Research Institute, Fort Rucker, AL), and D. SAWAL IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1503-1513. refs (Contract DAAH01-87-D-0035)

(AIAA PAPER 90-3481) Copyright

This paper presents an approach to the application of flight simulators for automated training of novice student pilots with limited human interaction. A hypothesis for automated human training is presented and based on this hypothesis, a synthesis procedure for a simulator-based automated hover trainer is developed. The synthesis uses the theory of optimal control pilot modeling for designing varying levels of stability augmentation, which mimics certain aspects of an instructor pilot. The simulator implementation of the hover trainer utilizes an adaptive loop to provide continuous augmentation level changes based on the students' learning curve. Experimental verification of the hypothesis, using a group of neophytes, showed that neophytes could be successfully trained using the automated hover trainer. Author

A90-47751#

ROBUST LOW NORM OUTPUT FEEDBACK DESIGN FOR FLIGHT CONTROL SYSTEMS

R. J. PATTON (York, University, England) and S. P. BURROWS IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1711-1719. refs

(AIAA PAPER 90-3505) Copyright

The problem of eigenvalue assignment in linear systems using a constant output feedback matrix is considered in this paper. A new way of finding an output feedback matrix of small norm which

assigns a given set of eigenvalues (chosen from some prespecified regions of the complex plane) so as to be insensitive to perturbations or parameter variations in the system matrices is presented. The output feedback control law is computed by starting with a parametric representation of the full state gain matrix. The technique involves the numerical minimization of a scalar cost function with a gradient-based optimization method using an analytically derived gradient vector. The proposed method provides a more flexible approach to the robust assignment of the eigenvalues of a controlled system. Author

A90-47753#

AN ORTHOGONAL ALGORITHM TO THE MAXIMUM LIKELIHOOD ESTIMATION USING AN EFFICIENT METHOD FOR COMPUTING SENSITIVITIES

PINGYUAN CUI, YAOHUA WU, and DI YANG (Harbin Institute of Technology, People's Republic of China) IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1729-1733. Research supported by the National Natural Science Foundation of the People's Republic of China. refs

(AIAA PAPER 90-3507) Copyright

In this paper, a new identification method to estimate aerodynamic coefficients is presented. This method is proposed for estimating sensitivities when Maximum Likelihood estimation is applied to estimate aerodynamic coefficients of aircraft. Here inverse matrix calculation is simplified by the concept of orthogonal test and orthogonal table. By this algorithm the inverse of the initial matrix in the modified Newton-Raphson scheme with estimated sensitivities (MNRES) is obtained. This orthogonal algorithm may be used for estimating a great number of aerodynamic parameters without any difficulty as in other appropriate methods. Author

A90-47755*# Houston Univ., TX.

A LINEAR QUADRATIC REGULATOR APPROACH TO THE STABILIZATION OF UNCERTAIN LINEAR SYSTEMS

L. S. SHIEH (Houston, University, TX), J. W. SUNKEL (NASA, Johnson Space Center, Houston, TX), and Y. J. WANG IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1742-1749. refs

(Contract DAAL03-87-K-0001; NAG9-380; NAG9-385)

(AIAA PAPER 90-3509) Copyright

This paper presents a linear quadratic regulator approach to the stabilization of uncertain linear systems. The uncertain systems under consideration are described by state equations with the presence of time-varying unknown-but-bounded uncertainty matrices. The method is based on linear quadratic regulator (LQR) theory and Liapunov stability theory. The robust stabilizing control law for a given uncertain system can be easily constructed from the symmetric positive-definite solution of the associated augmented Riccati equation. The proposed approach can be applied to matched and/or mismatched systems with uncertainty matrices in which only their matrix norms are bounded by some prescribed values and/or their entries are bounded by some prescribed constraint sets. Several numerical examples are presented to illustrate the results. Author

A90-47758#

NONCONVEX POLYTOPE APPROXIMATIONS OF ATTRACTING BASIN BOUNDARIES FOR NONLINEAR SYSTEMS

MARK L. PSIAKI (Cornell University, Ithaca, NY) and YIH-PING LUH IN: AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 1761-1766.

(AIAA PAPER 90-3512) Copyright

The paper presents an algorithm that estimates the attracting basin boundary for a stable equilibrium point of a nonlinear system.

The application of the method to a third-order PID control system, a fourth-order balancing peg-leg robot system, and a fourth-order lateral/directional aircraft system is described. It is noted that the algorithm can work with a system of any order. However, the computation time and memory requirements can grow rapidly with the state space dimension. K.K.

A90-48867#

EXPERT SYSTEM TECHNOLOGY APPLIED TO THE AUTOMATIC CONTROL OF MULTIPLE UNMANNED AERIAL VEHICLES

PAT H. MCINGVALE and SHARON E. DUDLEY (U.S. Army, Guidance and Control Directorate, Redstone Arsenal, AL) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 7 p. (AIAA PAPER 90-3280)

A concept has been proposed for an automatic controller that would enable a single operator to control multiple unmanned aerial vehicles through the application of expert system technology. A prototype of such a controller has been developed through an Army Missile Command/Georgia Tech Research Institute program. It was believed that the only part of such a system not currently available was the expert system itself. Therefore, this development focused on the expert system with the remainder of the system being simulated. The system was evaluated in the laboratory at MICOM where it was shown that parameters from multiple air vehicles can be evaluated, potential problems or failures detected, and critical decisions made by the expert system without operator intervention. Author

A90-49123#

A EFFICIENT TECHNIQUE FOR MULTIOBJECTIVE DESIGN OPTIMIZATION

J. E. ROGAN (Georgia Institute of Technology, Atlanta) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 12 p. (AIAA PAPER 90-3291) Copyright

A technique for solving multiobjective design optimization problems found in the field of aircraft design is presented. First, multiobjective optimization problems are posed as Pareto-optimality problems, and then a design problem is decomposed into subproblems where each of the design goals is assigned to a separate subproblem. A parameter passing scheme is set up for such a decomposition which generates all of the Pareto-optimal solutions. The application of the proposed method is illustrated with two examples: a box-shaped container and long-range aircraft, and it is demonstrated that solutions obtained are identical to the explicit solutions found earlier. It is also noted that the technique improves communication between customers and designers. V.T.

A90-49271#

APPLICATION POSSIBILITIES OF EXPERT SYSTEMS IN MODERN MAINTENANCE FOR INCREASING OPERATIONAL SECURITY [EINSATZMOEGlichkeiten VON EXPERTENSYSTEMEN IN MODERNEN WARTEN ZUR ERHOEHUNG DER BETRIEBSsICHERHEIT]

BERND BURGER (Colenco AG, Baden, Switzerland) Ortung und Navigation (ISSN 0474-7550), no. 1, 1990, p. 56-68. In German.

The major areas of application of expert systems in maintenance are surveyed. The 'Stuttgart Airfield' expert system is examined in detail, including its data processing, on-line and off-line modes, and expert components. The results achieved using this system are briefly addressed. C.D.

A90-49741

A BLACKBOARD APPROACH FOR DIAGNOSIS IN PILOT'S ASSOCIATE

BRUCE POMEROY and RUSSELL IRVING (GE Corporate Research and Development Center, Schenectady, NY) IEEE Expert (ISSN 0885-9000), vol. 5, Aug. 1990, p. 39-46. Research

supported by DARPA. refs
(Contract F33615-85-C-3804)
Copyright

A description is given of Pilot's Associate (PA), a control-advisory system expected to fly in late-1990s tactical fighter aircraft. PA will improve pilot effectiveness by improving pilot awareness of not only external situations but also the internal status of aircraft systems and options for accommodating faulty equipment. A blackboard architecture was used in developing the internal-awareness function, called system status. To get a clearer view of system status functionality, several examples are given to show how it aids pilots and supports other PA functions. System status architecture is described. Performance testing and evaluation results for PA are presented. Positive characteristics and drawbacks of the current architecture are summarized. I.E.

N90-27623# MicroNet, Celle (Germany, F.R.).

AIMS TEST AND SIMULATION EQUIPMENT

ANTON BADER /in DLR, Aircraft Integrated Monitoring Systems p 119-141 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

A new concept for a high flexible and versatile Aircraft Integrated Monitoring System (AIMS) test system is described. The outstanding performance of the equipment is based on multiprocessor architecture (Inmos transputer). The tester's software is written in OCCAM, a parallel programming language. The advantages of the new concept are compared against the conventional test system concepts. The realization of a stationary AIMS test system based on the new concept is shown. A portable and stationary system compatible AIMS tester is described. ESA

N90-27628# Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany, F.R.).

ADVANCED ALGORITHMS DESIGN AND IMPLEMENTATION IN ON-BOARD MICROPROCESSOR SYSTEMS FOR ENGINE LIFE USAGE MONITORING

J. BROEDE and H. PFOERTNER /in DLR, Aircraft Integrated Monitoring Systems p 241-260 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Advanced engine life usage monitoring requires close equivalence between mechanical design and monitoring algorithms in order to achieve sufficient accuracy. Usual and abnormal engine operation must be covered as well as input signal failure and other disturbance factors. The algorithms developed to satisfy the constraints due to processor speed and storage size are described. Those algorithms are embedded in a frame controlling the functional sequence of the monitoring procedure. Algorithm development includes the conversion into a suitable form for processing and the verification and validation of the implemented software. ESA

N90-27634# Flight Data Co., London (England).

REPLAY AND TRANSMISSION OF AIMS-DATA TO MAINFRAME COMPUTER USING REMOTE TRANSCRIBERS

PETER WALLER /in DLR, Aircraft Integrated Monitoring Systems p 351-369 Jan. 1990

Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Each engineer who makes decisions about aircraft and their operation has a desktop computer terminal. Each terminal allows access to a database of raw and processed information on all aspects of the operation. Part of this database contains the analyzed results from Aircraft Integrated Monitoring Systems (AIMS) data, and the full extent of the raw data recorded on each aircraft. To place the data into the mainframe with minimum manpower and delay, an actual system is described. It reads up to three data cartridges simultaneously and transcribes all data through a

fiber optic link into the mainframe. Present performance and future growth capability are discussed. ESA

N90-27635# Penny and Giles Data Recorders Ltd. (England). **FLIGHT DATA REPLAY AND ANALYSIS SYSTEM** ALAN BOND and MADS H. BRANDT (Scandinavian Airlines System, Oslo, Norway) *In* DLR, Aircraft Integrated Monitoring Systems p 371-390 Jan. 1990
 Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

A simple, low cost Personal Computer (PC) based system for the replay of quick access recorders and flight data recorders is described. The management of the resultant data for flight-ops, flight safety and maintenance purposes are discussed. It is demonstrated how the basic system may be expanded by networking a number of PC's together. ESA

N90-27645# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuehrung. **AUTOMATION OF THE READOUT, TRANSCRIPTION AND EVALUATION OF DIGITAL FLIGHT DATA AT DLR** KURT KLEIN *In its* Aircraft Integrated Monitoring Systems p 593-620 Jan. 1990
 Avail: NTIS HC A25/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 160 Deutsche marks

Technical innovations initiated an improvement of the Aircraft recorder transcription and analysis system at the Institute of Flight Guidance at DLR. The aim of the improvement is to be able to read modern recorders in a comfortable and computer aided way. The management of the system is computer based. The different recorder types, parameter positions within the recorded frames and conversion functions lead to a software concept with several data bases. This software uses commercial products with necessary additions and a new shell. The system is easy to use and the error sources are reduced to a minimum. ESA

N90-28366*# Computer Sciences Corp., Hampton, VA. **ADVANCED TRANSPORT OPERATING SYSTEM SOFTWARE UPGRADE: FLIGHT MANAGEMENT/FLIGHT CONTROLS SOFTWARE DESCRIPTION** WINSTON C. CLINEDINST, KELLY R. DEBURE, RICHARD W. DICKSON, WILLIAM J. HEAPHY, MARK A. PARKS, CHRISTOPHER J. SLOMINSKI, and DAVID A. WOLVERTON Jan. 1988 762 p
 (Contract NAS1-17999)
 (NASA-CR-181936; NAS 1.26:181936; TAO-50277) Avail: NTIS HC A99/MF A04 CSCL 09/2

The Flight Management/Flight Controls (FM/FC) software for the Norden 2 (PDP-11/70M) computer installed on the NASA 737 aircraft is described. The software computes the navigation position estimates, guidance commands, those commands to be issued to the control surfaces to direct the aircraft in flight based on the modes selected on the Advanced Guidance Control System (AGSC) mode panel, and the flight path selected via the Navigation Control/Display Unit (NCPU). Author

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A90-46192
ACTIVE CONTROL OF SOUND TRANSMISSION THROUGH A CYLINDRICAL SHELL
 D. R. THOMAS, P. A. NELSON, and S. J. ELLIOTT (Southampton,

University, England) *IN: Structural vibration and acoustics; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 267-269.*

Copyright

The work presented in this paper aims to predict the effectiveness of using secondary forces on the fuselage of a turbo-prop aircraft to control the transmission of tonal propeller noise into the passenger cabin. The fuselage is modeled by a thin cylindrical shell. Goldenveizer-Novozilov theory is used to predict the structural response of the shell to a distributed primary force, used to model the external pressure field, and a number of discrete secondary control forces. The predictions made by using this model in computer simulations suggest that the use of secondary forces may be an effective means of controlling the acoustic field in a turbo-prop driven aircraft. Author

A90-46351
THEORETICAL STUDIES OF THE ACTIVE CONTROL OF PROPELLER-INDUCED CABIN NOISE

A. J. BULLMORE, P. A. NELSON, and S. J. ELLIOTT (Southampton, University, England) *Journal of Sound and Vibration* (ISSN 0022-460X), vol. 140, July 22, 1990, p. 191-217. Research supported by the Department of Trade and Industry of England. refs

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A simple analytical theory is used to model the fuselage structural response of a B.Ae. 748 aircraft as a finite, isotropic thin cylindrical shell, and the cabin acoustic response as a cylindrical room. Theoretical results are compared with measured flight data obtained on a test aircraft. It is shown that, provided that the theoretical external acoustic pressure forcing of the shell is representative of the measured propeller pressure field acting on the aircraft fuselage, then the simple model can yield structural and acoustic responses which show good agreement with the measured data. This model is used to predict the effectiveness of a 16 source/32 error sensor active noise control system when applied to the predicted cabin sound fields at the first (88 Hz) and second harmonic propeller blade passage frequencies. An attempt is made to reduce the average sound level over a head height plane covering all 48 passenger seats. Average reductions over the plane of the order of 14 dB for the fundamental frequency and 4 dB for the second harmonic frequency are predicted. These results involve local reductions of up to 35 dB, but the spatial extent of these high-level reductions is shown to be considerably smaller for the second harmonic frequency than the fundamental frequency. Author

A90-46352
IN-FLIGHT EXPERIMENTS ON THE ACTIVE CONTROL OF PROPELLER-INDUCED CABIN NOISE

S. J. ELLIOTT, P. A. NELSON, I. M. STOTHERS, and C. C. BOUCHER (Southampton, University, England) *Journal of Sound and Vibration* (ISSN 0022-460X), vol. 140, July 22, 1990, p. 219-238. Research supported by the Department of Trade and Industry of England. refs

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Results are presented of a series of in-flight experiments on the active control of propeller-induced passenger cabin noise in a B.Ae. 748 aircraft. Twenty-six configurations of up to 16 loudspeakers and 32 microphones were investigated at the first three harmonics of the blade passage frequency. Two loudspeaker distributions, which were either evenly distributed or partly concentrated in the plane of the propellers, gave similar reductions in the sum of the squares of the measured pressures at the fundamental blade passage frequency (88 Hz) of about 13 dB. Concentrating the loudspeakers near the propeller plane increased the reductions in the second and third harmonics (176 Hz and 264 Hz) from about 9 dB and 6 dB respectively for the equally distributed system, to about 12 dB for both harmonics. Subjective reductions in noise level with all three harmonics being simultaneously controlled were pronounced, with reductions of over

7 dB(A) being recorded at some seat locations. Also reported are additional experiments, with a local (two-loudspeaker, two-microphone) control system used for a single seat, and with the 16 loudspeaker, 32 microphone control system used to control the noise inside the cabin when the engines were run-up on the ground. Author

A90-46506

A SOURCE OF DISCRETE NOISE COMPONENTS IN THE FLOW PATH OF GAS TURBINES AND FANS [OB ODNOI PRICHINE VOZNIKNOVENIIA DISKRETYKH SOSTAVLIAIUSHCHIKH SHUMA V TRAKTAKH GAZOVYKH TURBIN I VENTILIATOROV]

A. V. BAIKOV and V. N. IAROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1990, p. 97-99. In Russian. Copyright

The central spinner used downstream of the rotor to improve the exhaust channel aerodynamics may lead to a significant amplification of noise in axial-flow blading machinery. Here, the noise amplification process is investigated analytically using a linear model. The boundary conditions are expressed in terms of impedances, and the problem is reduced to an analysis of the change in the impedance of the cross section of interest due to an additional acoustic resonator representing the hollow spinner. The results obtained are consistent with experimental data. V.L.

A90-46552

CALCULATION OF THE ROTATION NOISE OF A SINGLE PROPELLER WITH BLADES OF ARBITRARY SHAPE [O RASCHETE SHUMA VRASHCHENIIA ODINOCHNOGO VINTA S LOPASTIAMI PROIZVOL'NOI FORMY]

V. I. GANABOV and A. G. MUNIN TsAGI, Uchenye Zapiski (ISSN 0321-3439), vol. 20, no. 5, 1989, p. 43-52. In Russian. refs

Copyright

An analytical method is proposed for calculating the rotation noise of a propeller with blades of arbitrary planform, including saber-shaped blades. The calculation procedure uses the specified geometrical and aerodynamical characteristics of the propeller determined at the stage of preliminary aerodynamic design. The aerodynamic load is prescribed over the entire surface of the blade. An expression is obtained for determining the acoustic pressure level in the near and far fields. The results obtained are compared with experimental data. V.L.

A90-46947*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE ROTONET PREDICTION SYSTEM AND INITIAL COMPARISONS WITH FAR-FIELD ACOUSTICS

MEASUREMENTS FOR THE XV-15 TILT-ROTOR AIRCRAFT

ROBERT A. GOLUB (NASA, Langley Research Center, Hampton, VA) and DONALD S. WEIR (Lockheed Engineering and Sciences Co., Hampton, VA) IN: Vertical Lift Aircraft Design Conference, San Francisco, CA, Jan. 17-19, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 19 p. refs

The NASA Langley Research Center is developing the ROTONET prediction system, a comprehensive computer program for the prediction of full system rotorcraft noise, to provide an analytical tool for estimating the total noise signature of rotorcraft. It contains models of many rotorcraft noise generating mechanisms. NASA is also performing a series of flight tests to provide comprehensive validation data bases for the ROTONET System. A joint NASA/Bell Helicopter Textron Incorporated test of an XV-15 tilt-rotor aircraft is one of several flight test which has been performed. A data base consisting of spectra, noise level time histories, and effective perceived noise levels, incorporating actual meteorological conditions, and tilt-order aircraft flight dynamics, is being produced from this test. The ROTONET prediction system is described, the flight test methodology is explained, and initial comparisons are shown of ROTONET predictions with data from the flight test. EPNL, noise level time history, and narrowband noise spectra comparisons demonstrate the overall capabilities of the prediction system. Author

A90-47202*# Pratt and Whitney Aircraft Group, East Hartford, CT.

MIXER-EJECTOR NOZZLE FOR JET NOISE SUPPRESSION

W. K. LORD, C. W. JONES, A. M. STERN (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT), V. L. HEAD, and E. A. KREJSA (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASSEE, Joint Propulsion Conference, 26th, Orlando, FL, July 16-18, 1990, 20 p. refs (AIAA PAPER 90-1909) Copyright

An aero/acoustic model test of a mixer-ejector nozzle was conducted at the 9 x 15 foot low-speed acoustic wind tunnel at NASA Lewis Research Center. The objective of the test was to get a preliminary assessment of ejector pumping and noise reduction potential of this device for possible application in the exhaust system of an advanced supersonic civil transport. The results of the test showed that goal levels of pumping were achieved. Exit pressure/temperature traverse data showed that there was good mixing between the primary and secondary streams. Acoustics data were dominated by shock noise; jet mixing noise levels were low because of a facility limit on primary temperature. The mixer-ejector did significantly reduce shock noise relative to the baseline conic nozzle. Because the relative magnitudes of jet mixing noise and shock noise were not in the correct proportion to properly model engine noise, an Effective Perceived Noise Level (EPNL) assessment was precluded. Author

A90-48657

THE GAS SOURCE MOLECULAR BEAM EPITAXIAL GROWTH OF AL(X)GA(1-X)P ON (100) GAP

J. N. BAILLARGEON, K. Y. CHENG, K. C. HSIEH, and G. E. STILLMAN (Illinois, University, Urbana) Journal of Applied Physics (ISSN 0021-8979), vol. 68, Sept. 1, 1990, p. 2133-2139. Research supported by AT&T Affiliates Program. refs (Contract N00014-90-J-1270; NSF ECD-89-43166)

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A detailed investigation necessary for achieving good morphology of Al(x)Ga(1-x)P growth on (100) GaP for Al mode variations ranging between 0 and 1 is presented. The reflection high energy electron diffraction pattern of the GaP surface indicates that an exponential increase in the incident P₂ flux is required to maintain good morphology at temperatures higher than 690 C. The addition of Al to the surface substantially increases the Ga congruent vaporization temperature from the GaP surface. The growth rates of Al(x)Ga(1-x)P as a function of growth temperature between 600 and 750 C are determined by TEM. Free electron concentrations as high as 1.65 x 10 to the 19th/cu cm in GaP and 1.5 x 10 to the 10th/cu cm in Al(0.28)Ga(0.72)P are achieved. Such high-temperature electronics has significant implications for aircraft engines. C.D.

A90-48957#

TWIN-JET SCREECH SUPPRESSION

LEONARD SHAW (USAF, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, Aug. 1990, p. 708-715. Previously cited in issue 13, p. 2052, Accession no. A89-33768. refs

A90-49481

AN ANALYSIS OF CAVITY RESONANCE IN THE AEROENGINE CASING DURING RIG TESTING

TONGQING WANG, YUANSHEG SHENG (Shenyang Institute of Aeronautical Engineering, People's Republic of China), and EJUN XU (Shenyang Aeroengine Research Institute, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 377-381. refs

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A pure tone which occurred in the prototype of a turbojet during rig testing was studied. It has been pointed out that the pure tone arises from the Helmholtz resonance in a ring cavity outside of the compressor casing which is originally designed to

reduce instability of air flow during engine transient process in a way to match the high- and low-pressure compressor. When the frequency of cavity resonance is in coincidence with that of the casing structure, resonance of such a tone will be strongly radiated. For studying such a phenomenon, the formulas of acoustic radiation impedance of a circular hole on the infinitely rigid plate and the mathematic model of Helmholtz resonance in the ring cavity with multiholes were explored. The consequences of calculation are conformable to the results measured in rig testing. Author

A90-49484

ON THE UNSTEADY LOADING NOISE OF COUNTER-ROTATING PROPELLER

XIAO-FENG SUN, ZONG-AN HU, and SHENG ZHOU (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 401-406. refs Copyright

The mechanism of noise generated by a counter-rotating propeller or propfan is quite different from that of a single-rotating one. The mechanism of unsteady loading noise generated by interaction of a front rotor's wake with an aft rotor in a counter-rotating (CR) propeller has been analyzed and the set of corresponding noise radiation formulas has been derived. The numerical predictions of noise generated by a CR propeller are given and compared with published experimental data. It appears that the sound pressure level (SPL) in the axial direction of the rotor is fully determined by the component of unsteady loading noise. However, in the rotating plane the main contribution to SPL comes from the component of steady loading noise, and the effect of unsteady loading noise is just limited in the range of higher harmonics. Author

A90-49485

ON NUMERICAL PREDICTION OF SOUND FIELD GENERATED BY PROPELLER

LI-XI HUANG, XIAO-FENG SUN, and SHENG ZHOU (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 407-414. Copyright

A numerical prediction method and free space field of propeller noise is presented. The near sound field radiated by noncompact sources is calculated by a retarded time integration in time domain technique. The method distinguishes itself from many others by its features of no extra partial differentials or singularities; therefore, it is accurate and efficient. Some comparisons of calculations with test results showed that the method and code could be used as an engineering tool. Author

A90-49486

NOISE GENERATION BY SWEEP CASCADE

XIAOFENG SUN, ZONGAN HU, and SHENG ZHOU (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: Unsteady aerodynamics and aeroelasticity of turbomachines and propellers; Proceedings of the Fifth International Symposium, Beijing, People's Republic of China, Sept. 18-21, 1989. Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, p. 415-426. refs Copyright

A theoretical model for analysing the aeroacoustic nature of swept cascade is described. Some closed form expressions for the acoustic pressure and acoustic power in far field are obtained. These expressions are used in parametric calculations of rotor viscous wake-stator vane interaction in order to study the effectiveness of sweep as a noise reduction mechanism. It is concluded that the sweep angle plays an important role in the

generation of noise of cascade, in some cases, however, the sweep angle does not result in the reduction of noise generated by the interaction of rotor viscous wakes with a stator vane.

Author

N90-27465*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

THE VALIDATION AND APPLICATION OF A ROTOR ACOUSTIC PREDICTION COMPUTER PROGRAM

JUDITH M. GALLMAN 1990 16 p
(NASA-TM-101794; NAS 1.15:101794; AD-A227275) Avail: NTIS HC A03/MF A01 CSCL 20/1

An essential prerequisite to reducing the acoustic detectability of military rotorcraft is a better understanding of main rotor noise which is the major contributor to the overall noise. A simple, yet accurate, Rotor Acoustic Prediction Program (RAPP) was developed to advance the understanding of main rotor noise. This prediction program uses the Ffowcs Williams and Hawkins (FW-H) equation. The particular form of the FW-H equation used is well suited for the coupling of the measured blade surface pressure to the prediction of acoustic pressure. The FW-H equation is an inhomogeneous wave equation that is valid in all space and governs acoustic pressure generated by thin moving bodies. The nonhomogeneous terms describe mass displacement due to surface motion and forces due to local surface stresses, such as viscous stress and pressure distribution on the surface. This paper examines two of the four types of main rotor noise: BVI noise and low-frequency noise. Blade-vortex interaction noise occurs when a tip vortex, previously shed by a rotor blade, passes close enough to a rotor blade to cause large variations in the blade surface pressures. This event is most disturbing when it happens on the advancing side of the rotor disk. Low-frequency noise includes hover and low to moderate speed forward flight. For these flight conditions, the low frequency components of the acoustic signal dominate. GRA

N90-27466# Aerospace Medical Research Labs., Wright-Patterson AFB, OH.

AIR FORCE PROCEDURE FOR PREDICTING AIRCRAFT NOISE AROUND AIRBASES: AIRBASE OPERATIONS PROGRAM (BASEOPS) DESCRIPTION Technical Report, Jul. 1988 - Jan. 1990

ROBERT A. LEE and HENRY T. MOHLMAN Jan. 1990 82 p
(Contract AF PROJ. 7231)
(AD-A223069; AAMRL-TR-90-012) Avail: NTIS HC A05/MF A01 CSCL 20/1

A user manual is presented for the BASEOPS 3.00 program developed by AAMRL/BBE. The installation, use and limitations of this program is described. BASEOPS is the menu driven computerized airbase operations input program used in doing airbase noise assessments under the USAF Air Installation Compatible Use Zone (AICUZ) program. BASEOPS will create a file that can be directly interfaced to the NOISEMAP 6.0 program, used to calculate the total noise exposure from these input operations. BASEOPS contains default performance profiles (takeoff and landing) for Military Transient and Civil aircraft. The program also allows the user to create a NOISEMAP input file for any subset of the input data through a Global Editing Menu. This can be used for quickly creating multiple noise analyses for different operational input scenarios. GRA

N90-27467# Wyle Labs., Inc., El Segundo, CA.

AIR FORCE PROCEDURE FOR PREDICTING AIRCRAFT NOISE AROUND AIRBASES: NOISE EXPOSURE MODEL (NOISEMAP). USER'S MANUAL Final Report, Jul. 1988 - Jan. 1990

CAREY L. MOULTON Feb. 1990 138 p
(Contract F33615-89-C-0531; AF PROJ. 7231)
(AD-A223162; AAMRL-TR-90-011) Avail: NTIS HC A07/MF A01 CSCL 20/1

This report describes the NOISEMAP 6.0 Noise Exposure Model and is intended as a user's guide for these programs. The report provides operating details on the MCM, OMEGA 10 and 11, and

NMAP60 computer programs (which are all encompassed by the term NOISEMAP 6.0). The BASEOPS and NMPLT programs are also discussed but only in relation to their interaction with NOISEMAP 6.0. Information regarding the changes made between NOISEMAP 6.0 and older versions are listed and a methodology for converting older NOISEMAP decks to this new version is discussed. The limitations of NOISEMAP 6.0 are detailed. An example case is provided for a small joint-use airfield. Three general aviation categories are employed (single, twin, and jet) and one military designation. Appendix C provides a complete listing of all the military and civilian aircraft which are contained in NOISEFILE 6.0 including power settings and airspeeds. GRA

N90-27468# Defence Research Establishment Atlantic, Dartmouth (Nova Scotia).

NOISE FROM TIP VORTEX AND BUBBLE CAVITATION

NEIL C. SPONAGLE Mar. 1990 41 p
(AD-A221962; DREA-TM-90/202) Avail: NTIS HC A03/MF A01 CSCL 20/1

This paper presents results from experiments designed to study the sound from different types of propeller cavitation. The propellers used in the tests produced tip vortex and travelling bubble cavitation. The spectral content, directivity, and waveform of the far-field sound were measured, in essentially free-field conditions up to 100 kHz. These data were then correlated with information about the cavity dynamics, obtained from visual observations. Vibrational modes on the tip vortex cavities produced sound at characteristic frequencies. Bubble cavitation by itself produced very broadband noise, and strongly affected the vortex cavitation noise mechanisms if the free bubbles entered the tip vortices. The noise from both kinds of cavitation was directional. GRA

N90-27469# Army Aviation Development Test Activity, Fort Rucker, AL. Human Factors Engineering Div.

AVIATION ACOUSTICAL NOISE MEASUREMENT Final Report

RON SMITH Feb. 1990 24 p
(AD-A222014; TECOM-7-CO-R89-AVO-004) Avail: NTIS HC A03/MF A01 CSCL 20/1

U.S. Army Aviation Development Test Activity investigated methodology for planning, collecting, analyzing, and reporting steady-state acoustical noise parameters of U.S. Army aviation systems. It was concluded that: Planning for development of future aviation systems should incorporate extensive acoustical analysis to minimize the negative impact of environmental noise on personnel. Acoustical analysis should be incorporated as early as possible during the development process so that appropriate corrective action can be initiated. Previous experience has demonstrated that system design which incorporates appropriate acoustical protection is less expensive to develop than noise reduction programs after the system is operational. It was recommended that a formal Test Operations Procedure (TOP) be developed which describes standardized procedures for planning, execution, collection, analysis, and reporting of steady-state acoustical noise parameters within current/future U.S. Army aviation systems. GRA

N90-27471*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE ACOUSTIC RESULTS OF A UNITED TECHNOLOGIES SCALE MODEL HELICOPTER ROTOR TESTED AT DNW

SANDY R. LIU (Army Aviation Systems Command, Moffett Field, CA.) and MICHAEL A. MARCOLINI May 1990 20 p Presented at the 46th Annual Forum of the American Helicopter Society, Washington, DC, May 1990
(NASA-TM-101879; NAS 1.15:101879; AD-A22532) Avail: NTIS HC A03/MF A01 CSCL 20/1

In a major cooperative program between U.S. Government agencies (represented by the U.S. Army Aeroflightdynamics Directorate and NASA Ames and Langley Research Centers) and United Technologies Corp. A 1/6 geometrically and aeroelastically scaled UTC model helicopter rotor was tested in the open-jet anechoic test section of the Duits-Nederlandse Windtunnel in the Netherlands. As the fourth entry under the Aerodynamic and

Acoustic Testing of Model Rotors Program, several comprehensive acoustic and aerodynamic databases were obtained relating the important aerodynamic phenomena to both the near- and far-field acoustic radiation. In particular, high speed impulsive noise, and blade-vortex interaction are of primary interest. This paper provides an initial summary of the acoustic measurements acquired for some of the different configurations tested. A review of the baseline swept tip rotor acoustic characteristics in the regimes of high speed forward flight, where high speed impulsive noise dominates, and low speed descent, where severe blade vortex interaction noise occurs, is presented. The trends of these primary noise sources are studied as the first step in validating the data for release and application. GRA

N90-28396*# Southwest Research Inst., San Antonio, TX.
STRUCTURE-BORNE NOISE ESTIMATES FOR THE PTA AIRCRAFT

JAMES F. UNRUH Washington NASA Aug. 1990 61 p
(Contract NAS1-17921)
(NASA-CR-4315; NAS 1.26:4315; SRI-04-8542-2) Avail: NTIS HC A04/MF A01 CSCL 20/1

Estimates of the level of in-flight structure-borne noise transmission in the Propfan Test Assessment Aircraft were carried out for the first three blade passage frequencies. The procedure used combined the frequency response functions of wing strain to cabin sound pressure level (SPL) response obtained during ground test with in-flight measured wing strain response data. The estimated cabin average in-flight structure-borne noise levels varied from 64 to 84 dB, with an average level of 74 dB. The estimates showed little dependence on engine/propeller power, flight altitude, or flight Mach number. In general, the bare cabin noise levels decreased with increasing propeller tone, giving rise to a plausible structure-borne noise transmission problem at the higher blade passage tones. Without knowledge of the effects of a high insertion loss side wall treatment on structure-borne noise transmission, no quantitative conclusions could be made. Author

N90-28398# Technische Univ., Berlin (Germany, F.R.). Fachbereich Verkehrswesen.

A PROCESS FOR ANALYSIS, EVALUATION, AND DEVELOPMENT OF AERIAL SERVICING NOISE REDUCTION MEASURES IN CIVIL AIRCRAFT Ph.D. Thesis [EIN VERFAHREN ZUR ANALYSE, BEWERTUNG UND ENTWICKLUNG FLUGBETRIEBLICHER LAERMINDERUNGSMASSNAHMEN IM ZIVILEN LUFTVERKEHR]

1990 158 p In GERMAN
(ETN-90-97300) Avail: NTIS HC A08/MF A01

A correct evaluation of the sound emissions of the starting and landing passenger planes is realized on the basis of local three level histograms, which take into account meteorological and topographic sound broadening conditions. The process was analyzed by the system NOISIMSIS (Noise Impact Simulation System), whose principle is to consider the air traffic as a sum of single flight events, which are represented by a sequence of discrete emission points. The correlation of measured and forecast third level spectra were satisfying in the 50 to 250 Hz frequency area. ESA

N90-28402# Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction de la Physique Generale.
THEORETICAL STUDIES CARRIED OUT IN 1988 ON HELICOPTER ROTOR NOISE UNDER SUBSONIC CONDITIONS Final Report [ETUDES THEORIQUES MENEES EN 1988 SUR LE BRUIT DE RAIES D'UN ROTOR D'HELICOPTERE EN REGIME SUBSONIQUE, RAPPORT DE SYNTHESE]

M. CAPLOT and J. PERRET-LIAUDET Feb. 1989 107 p In ENGLISH and FRENCH
(Contract DRET-88-001-58)
(ONERA-RS-82/5094-PY; ETN-90-97495) Avail: NTIS HC A06/MF A01

The results of the investigations performed on helicopter rotor noise are summarized. Subsonic conditions where thickness and

charge dominate are considered. A new version of the noise program field hypothesis, is presented. The calculation of the loading noise is improved. The calculation of the parameters of thickness and load are coupled and their results synchronized. The noise of the blade-vortices interaction is estimated. Improvements for the rotor three dimensional calculations are suggested. ESA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A90-46629

THE ECONOMICS OF THE ORGANIZATION AND THE PLANNING OF CIVIL AVIATION [EKONOMIKA, ORGANIZATSIIA I PLANIROVANIE GRAZHDANSKOI AVIATSII]

GEORGII S. DIBROVA, EVGENII P. LISIN, and ARNOL'D N. KHIZHNIK Moscow, Izdatel'stvo Transport, 1989, 264 p. In Russian. refs

Copyright

Economic and planning philosophy is elaborated for civil aviation in the Soviet Union. Particular attention is given to the basic resources of civil aviation, the costs of production, the effectiveness of capital expenditures and new technology, patents and inventions, the organization and planning of aircraft maintenance, the operation of civil-aviation enterprises, the use of automated planning and control techniques, and personnel management. B.J.

A90-46648

RECENT DEVELOPMENTS IN EEC AVIATION LAW - 'THE SECOND PHASE'

EUGENIE L. M. KALSHOVEN-VAN TIJEN (KLM Royal Dutch Airlines, Schiphol Airport, Netherlands) Air Law (ISSN 0165-2079), vol. 15, June 1990, p. 122-139. refs

Copyright

The efforts of EEC member states to create a common transport policy are discussed. The first and second phases of scheduled air transportation liberalization in Europe are outlined. It is noted that the adoption of the EEC Package on Air Transport, which consists of four separate legal instruments concerning tariff procedures, traffic rights, market access and capacity sharing, and anti-trust, began the first phase of air transportation liberalization. Measures which will govern the second phase with regard to access, capacity, pricing, cargo, and external relations were adopted by the Council of Transportation and Ministers on June 18, 1990. The legal instruments implemented in both the first and second phases are examined and their overall impact is examined. L.K.S.

A90-46649

CONSIDERATIONS ON THE LEGAL REGULATION OF AIR TRANSPORT IN THE NEAR FUTURE

FEDERICO VIDELA ESCALADA (Buenos Aires, Universidad, Argentina) Air Law (ISSN 0165-2079), vol. 15, June 1990, p. 140-148. refs

Copyright

The nature of international air transportation law is considered and the functions of both international organizations, such as the ICAO, and the government of each country in relation to air law are discussed. The legal aspects of air transportation contracts and the relationships between carriers are discussed. It is pointed out that the growth of civil aviation demands the unification of the rules underlying air transportation contracts, particularly in areas such as carrier liability. L.K.S.

A90-48842#

FIGHTER DESIGN ECONOMETRICS = OWNERSHIP AFFORDABILITY?

JIM BENNETT (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 7 p. refs (AIAA PAPER 90-3223) Copyright

Over the years the variety of fighter types has been reduced. Cost growth has also reduced the quantities. Schedule stretching, the other alternative, further inflates unit cost by prorating research and development over fewer airplanes. In addition, the cost of operation and support has been climbing with fighter flyaway cost. The increasing importance of fighter economics intensifies the need for effort in the opening hours of concept formulation. The fighter effectiveness indexes of exchange ratio, sortie rate, combat readiness and mission reliability are discussed. First steps to meet ownership cost goals begin with operational requirements studies, major trades at conception and making the tough choices for the effectiveness/economic balance and affordability. Author

A90-48843#

COMMERCIAL AIRCRAFT DOC METHODS

GEORGE W. VAN BODEGRAVEN (Boeing Commercial Airplanes, Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 7 p. (AIAA PAPER 90-3224) Copyright

The Air Transport Association (ATA) Direct Operating Cost (DOC) formula was last updated in 1967. This paper summarizes what Boeing has done since then. Improvements in methodology such as evaluating ownership costs of an airplane on a Life Cycle Cost (LCC) basis are included. The DOC method is a vital tool used by the manufacturers as well as the airlines in their airplane decision process. Author

A90-49121#

THE (AIRPLANE) DESIGN PROFESSOR AS SHEEPHERDER - AN INDUSTRY ROLE IN ENHANCING ENGINEERING EDUCATION

J. H. MCMASTERS and S. D. FORD (Boeing Commercial Airplanes, Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 38 p. refs

(AIAA PAPER 90-3259) Copyright

A series of recommendations is presented, with a view to the improvement of aeronautical engineering design education, which makes extensive use of aerospace industry expertise in the development of student skills. This initiative has been prompted by widespread evidence of excessive abstractness in university aeronautical engineering instruction, which frequently leaves students with little sense of how a major manufacturer actually designs, fabricates, and assembles a new aircraft. Significant percentages of faculty members involved in the teaching of aircraft design confess to very limited actual design experience, if any. A partnership between industry and academia is judged to be necessary to deepen students' understanding of solutions to realistic design problems. O.C.

A90-49613

LATIN AMERICAN CONFERENCE ON INTERNATIONAL AIR TRANSPORT AND ACTIVITIES IN OUTER SPACE, MEXICO CITY, MEXICO, AUG. 14-18, 1988, PROCEEDINGS [CONFERENCIA LATINOAMERICANA SOBRE TRANSPORTE AEREO INTERNACIONAL Y ACTIVIDADES EN EL ESPACIO ULTRATERRESTRE, MEXICO CITY, MEXICO, AUG. 14-18, 1988, RESULTADOS DE LA CONFERENCIA]

Conference sponsored by the Universidad Nacional Autonoma de Mexico. Leiden, Netherlands, International Institute of Air and Space Law, 1989, 563 p. In Spanish and English. For individual items see A90-49614 to A90-49624.

Copyright

The present conference discusses the relationship of the Chicago convention to the bilateral network, emerging privatization in Latin American air transport, liability in international air carriage,

insurance aspects of airline liability, the effects of currency fluctuations and taxes on airline revenues and tariffs, purchase and leasing financing for civil aircraft, and the conventions of Tokyo, the Hague, and Montreal. Also discussed are the role of ICAO in the control of narcotics trafficking and drug abuse, the experience of a decade of U.S. deregulation, a pluralistic framework for global air transport, the role of Latin America in outer space law, future space law, UN principles regarding remote sensing, telecommunications and the geostationary orbit, and the planning of space services using the GEO satellite orbit. O.C.

A90-49614

A REVIEW OF REGULATIONS - THE CHICAGO CONVENTION AND THE BILATERAL NETWORK [UNA REVISION DE LAS NORMAS - EL CONVENIO DE CHICAGO Y LA RED BILATERAL]

ANTONIO FRANCOZ RIGALT (Universidad Nacional Autonoma de Mexico, Coyoacan, Mexico) IN: Latin American Conference on International Air Transport and Activities in Outer Space, Mexico City, Mexico, Aug. 14-18, 1988, Proceedings. Leiden, Netherlands, International Institute of Air and Space Law, 1989, p. 31-44. In Spanish.

Copyright

After more than 40 years in operation, members of the Chicago Convention have deemed advisable a revision of regulations applying to international air transportation, as well as of the network of bilateral accords that define air routes globally. Attention is being given to the efforts of signatory states to protect their individual interest in the fostering of domestic travel agencies, hotels, and ground transportation. An additional focus of concern is the formulation and inclusion in the bilateral accords of a clause applying to the charter services that currently constitute 20 percent of total international air traffic. O.C.

A90-49615

INSURANCE ASPECTS OF AIRLINE LIABILITY [ASPECTOS DEL SEGURO DE RESPONSABILIDAD CIVIL DE LAS LINEAS AEREAS]

EDUARDO MEDINA URBIZU (Academia Mexicana de Derecho y Economia de los Transportes, Mexico) IN: Latin American Conference on International Air Transport and Activities in Outer Space, Mexico City, Mexico, Aug. 14-18, 1988, Proceedings. Leiden, Netherlands, International Institute of Air and Space Law, 1989, p. 125-131. In Spanish.

Copyright

From the international viewpoint, airline insurance liability laws are governed in matters of damage to passengers by the Warsaw (1929), the Hague (1955), Guadalajara (1961), and Montreal (1966) conventions; with respect to damage to persons and property on the ground, the Rome (1952) convention applies. An evaluation is presently made of the relationship of Latin American laws and statutes to existing international understanding of insurance liabilities. O.C.

A90-49616

FINANCING OF CIVIL AIRCRAFT - PURCHASES AND LEASING [FINANCIAMIENTO DE AERONAVES CIVILES - COMPRAS Y ARRENDAMIENTO]

WALDIR PINTO DA FONSECA (Departamento de Aviao Civil, Brazil) IN: Latin American Conference on International Air Transport and Activities in Outer Space, Mexico City, Mexico, Aug. 14-18, 1988, Proceedings. Leiden, Netherlands, International Institute of Air and Space Law, 1989, p. 157-165. In Spanish.

Copyright

An evaluation is made of recent trends in civil aircraft financing from the standpoint of developing countries, with emphasis on the relevance of leasing arrangements to the Latin American markets. The types of leasing extend from short-term operating leases and long-term capital leases to such novel arrangements as 'full service' or rental leasing, net-leasing (in which maintenance costs are borne by the lessee), and sale lease-back. An account is given of the business conditions in which leasing arrangements are most beneficial. O.C.

A90-49618

THE INTEGRATION OF LATIN AMERICAN TRANSPORT - REALITIES AND PERSPECTIVES [LA INTEGRACION DE TRANSPORTE AEREO LATINOAMERICANO - REALIDADES Y PERSPECTIVAS]

ERNESTO VASQUEZ ROCHA (Asociacion Internacional de Transporte Aereo Latinoamericano, Colombia) IN: Latin American Conference on International Air Transport and Activities in Outer Space, Mexico City, Mexico, Aug. 14-18, 1988, Proceedings. Leiden, Netherlands, International Institute of Air and Space Law, 1989, p. 239-272. In Spanish.

Copyright

An assessment is made of the effects of deregulation in the U.S. and Western Europe, and implications are drawn from experiences in these markets to date for the Latin American market. Attention is given to tariff liberalization, immediate Latin American consequences of deregulated foreign operations in the absence of local deregulation, consolidations among large air carriers, and the trend toward privatization of large air transport enterprises. An evaluation is made of the prospects for formation of continental blocks for negotiation traffic rights, and an anticipation of consequences from ongoing automation of airline systems and from the introduction of novel aircraft is attempted. O.C.

A90-49619

U.S. DEREGULATION - EVIDENCE FROM TEN YEARS OF EXPERIENCE

MICHAEL E. LEVINE (Yale University, New Haven, CT) IN: Latin American Conference on International Air Transport and Activities in Outer Space, Mexico City, Mexico, Aug. 14-18, 1988, Proceedings. Leiden, Netherlands, International Institute of Air and Space Law, 1989, p. 299-309. refs

Copyright

The present evaluation of U.S. experience with airline deregulation notes this policy change to have yielded many benefits, some of which nevertheless substantially deviate from the predictions of initial economic models which were too simple to accurately anticipate long-term effects. While some such deviations from projections may prevent the fullest approximation of perfect competition in a deregulated climate, the results nevertheless constitute a substantial improvement over the previous U.S. situation as well as over that which holds over regulated markets globally. Whether deregulations of foreign markets in the fashion pioneered by the U.S. will achieve comparable results remains an imponderable. O.C.

A90-49620

ANATOMY OF AIRLINE REGULATION - TOWARDS A PLURIFORM, PLURILATERAL, PLURALISTIC, FLEXIBLE WORLD-WIDE REGULATORY FRAMEWORK FOR AIR TRANSPORT

H. A. WASSENBERGH (Leiden, Rijksuniversiteit, Netherlands) IN: Latin American Conference on International Air Transport and Activities in Outer Space, Mexico City, Mexico, Aug. 14-18, 1988, Proceedings. Leiden, Netherlands, International Institute of Air and Space Law, 1989, p. 311-354.

Copyright

International air transport requires a globally implemented regulatory framework under a multilateral agreement of which plurilateral and regional modifications will be a structural manifestation. This framework will have to recognize that civil aviation will remain a government-controlled activity in many parts of the world. Since every sovereign state will retain the power with which to appropriate a share of international air traffic for its own carriers, it is anticipated that governments will remain avidly interested in the further development of international air transport. O.C.

N90-28463# Wichita State Univ., KS. National Inst. for Aviation Research.

EVALUATION OF EXISTING AIRCRAFT OPERATOR DATA BASES Final Report

JOHN HUTCHINSON, FRANK H. MACHEELS, and BARBARA K.

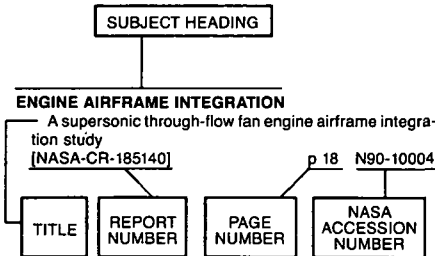
SMITH Aug. 1990 48 p
(Contract DTFA03-89-C-00057)

(DOT/FAA/CT-90/18) Avail: NTIS HC A03/MF A01

Existing sources of aircraft operator information were researched. The research determined the availability of aircraft operator information, assessed the factors involved in its acquisition, and evaluated the feasibility of using these data in an International Aircraft Operators Information System for the FAA. This evaluation was completed as part of the first phase of a two phase program to develop an operational aircraft operator information system. The system will include an operator data base and will use existing data from commercial data suppliers. Results of the search for available aircraft operator data from data suppliers, manufacturers, and other organizations indicate there are a number of data suppliers capable of providing more detail and better scope than those now available to the FAA.

Author

Typical Subject Index Listing



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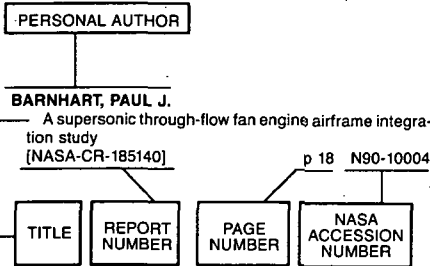
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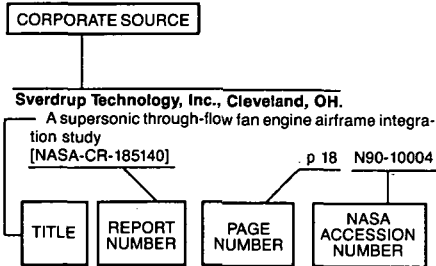
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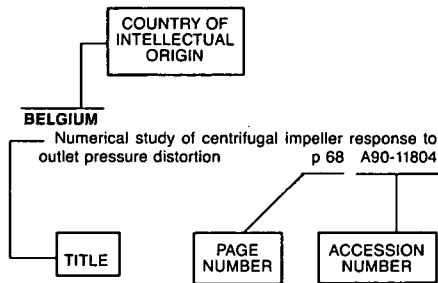
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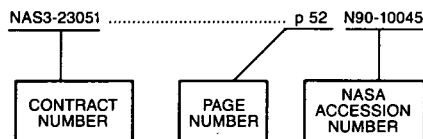
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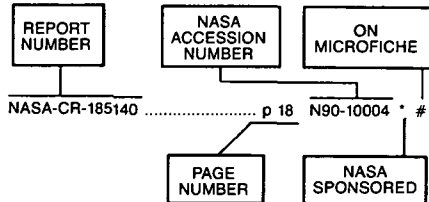
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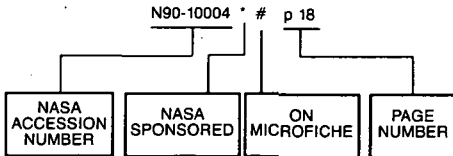
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DODA-AR-006-090	p 815	N90-26793	#	NAS 1.26:186222	p 844	N90-26824	* #				
DOT-TSC-FAA-90-1	p 824	N90-26805	#	NAS 1.26:186886	p 849	N90-27701	* #				
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